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CORRECTIONS

Volume 66, October 1948, page 273, column one, top paragraph, last sentence (c), after "The" insert "squares designate the". Page 275, column one, 15th line below the illustration, after the expression "plain crystals" insert, "can be obtained at the temperatures still nearer the freezing point."; page 277, 2d column, 16th line from bottom, for "no" read "not".

MONTHLY WEATHER REVIEW

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ON THE INTERPRETATION OF TEMPERATURE MEASUREMENTS MADE AT HIGH LEVELS

By J. C. BALLARD

[Weather Bureau Airport Station, New York, N. Y., January 1940]

INTRODUCTION

The continued and increasing interest in, and the progress being made in, the extension of meteorological observations to very high levels makes it desirable to extend our knowledge of the accuracy of those measurements. This is particularly true in the case of temperature measurements because there are sources of error in them which have not yet been satisfactorily evaluated. These causes of error are chiefly (*a*) the effect of insolation if the observations are made during the daytime, (*b*) the effect of radiation from the instruments during night observations, and (*c*) the effect of lag in the temperature elements. In this study it was attempted to evaluate the magnitudes of these effects in the sounding balloon data obtained by the Weather Bureau during the International Month July 1938, at Omaha, Nebr. A general description of sounding-balloon technique will be found in (1), and more recent details regarding the balloons used and the arrangement of equipment in (2).

The program of observations during the month of July 1938 included the release of 1 balloon daily about 90 minutes before sunset, 9 others on separate days immediately after sunset, and 10 more at the time of the regular aerological sounding on days different from those on which the post-sunset observations were made. The observations begun daily about 90 minutes before sunset will hereafter be referred to as the 6:00 p. m. observations, those begun immediately after sunset as the 8:00 p. m. observations, and those made in the early morning as the 2:00 a. m. observations. The actual times of observation ordinarily differed from these times by a half hour or less. Each balloon released carried both a Fergusson (3) and a Jaumotte (4) meteorograph with the exception of 1 which carried only a Fergusson meteorograph. The Jaumotte meteorographs used were of a type manufactured in this country, and the pressure mechanisms were so faulty that none of the pressure records can be relied upon. The temperature elements performed satisfactorily, however, so that the temperatures recorded by the 2 types of instruments can be compared at points which can be definitely identified as being synchronous on the two traces. Hence, the instrument chosen as the standard was the Fergusson type; and all of the data referred to were obtained from the records of those instruments except where specifically mentioned. Two-theodolite observations (5) of the balloons were made whenever the weather permitted. As a result of good weather, the use of a fairly high rate of ascent and the existence of relatively light winds, all but 10 of the balloons released at 6:00 p. m. were followed to the bursting point with 2 theodolites. The theodolite observations served as a check on the altitudes computed from the meteorograph records and were used as the standard in a few cases to correct the instrumental pressure records at very high elevations. An account of the winds obtained from the 2-theodolite observations will be found in (2).

The object in making the night flights, of course, was to obtain data for use in studying the effects of insolation and radiation on the instrument and in studying the possibility of a diurnal variation of temperature at high levels. The 6:00 p. m. observations differed, on the average, by about 90 minutes in time from the 8:00 p. m. flights and it was thought at the time the observations were made that any diurnal variation of temperature during this interval would be small, so that any observed differences in temperature between 6 and 8 p. m., at high levels, could be explained as being due to the sum of the effects of insolation and radiation. It was then expected that this effect could be removed from the 6 p. m. records so that the diurnal variation in temperature between 6 p. m. and 2 a. m. could be determined. The use of two different types of instruments which were not expected to be subject to the same insolation and radiation effects was expected to furnish further evidence as to whether the observed temperature changes were real.

INSOLATION AND RADIATION EFFECTS

The term radiation should properly include the effects of insolation by day and radiation at night, since both are radiation phenomena. However, for convenience of reference, the term "insolation effect" is used to indicate the effect on the recorded temperatures of the sun's radiation striking the meteorograph; and "radiation" is used to indicate the excess of outgoing over incoming radiation at night. The effect of insolation in causing the meteorograph to record a temperature higher than that of the ambient air stream depends upon the lag coefficient of the temperature element, the rate of ascent of the instrument, the density of the air stream, the absorption coefficient of the instrument case and radiation shielding, and upon the construction of the instrument (6), (7), (8), (9). It is difficult to evaluate theoretically for a given instrument the effects of the latter two of these factors so that the absolute error can be obtained. For this reason there is a definite advantage in having night observations to compare with day observations in studying the effect of insolation.

The first three of the above-named factors, namely, lag coefficient of the temperature element, rate of ascent, and air density are involved in the determination of the total insolation effect in the following manner: The smaller the lag coefficient, the nearer the instrument will record to the temperature of the passing air stream, considering lag alone. Air is flowed past the temperature element by the rise of the instrument so that rate of ascent is a measure of the rate of flow. It is assumed

that the instrument case and radiation shielding will absorb a certain amount of insolation and be at a somewhat higher temperature than the surrounding air. Hence, it is to be expected that if the rate of flow of air past the element is low enough some preheated molecules of air will reach the temperature element through turbulence within the ventilating tube. Radiation and conduction from the warmer case and shielding will further affect the temperature element. The net result, then, will be that the instrument will record temperatures higher than those in the undisturbed air. Obviously, the greater the rate of ascent the less the air stream will be heated by conduction and the more the instrument will be cooled by the air, so that a high rate of ascent reduces the effect of insolation. On the other hand, the rate of ascent cannot be made too great for the reason that the lag of the temperature element may then become important, since, in general, the temperature will be changing with altitude, and significant changes in the vertical temperature gradient will not be recorded by the instrument. The air density is an important factor since it enters with the velocity in determining the rate of removal of heat from the temperature element. The density decreases rapidly with increasing altitude while the rate of ascent remains substantially constant. Hence, the effective ventilation likewise decreases rapidly with increasing elevation, and it is to be expected that when it becomes small enough the instrument will begin to record too high temperatures. A given type of instrument having a given rate of ascent and ascending at a given time of day relative to sunrise or sunset should, then, begin to record a given amount of insolation effect at the same height every day, under not too different meteorological conditions.

During the Second International Polar Year a large number of sounding-balloon observations were made in this country. These observations were made in series, each consisting of three flights. The flights in each case were made near noon, midnight, and 6:00 a. m., C. S. T., thus covering an 18-hour period. These observations were studied (6) in an effort to determine the insolation effect on the Fergusson meteorographs and results were obtained which became quite significant at comparatively low elevations (see figure 1 of (6)). What was believed at that time to be insolation effect became important at about 10 km. in the case of the 6:00 a. m. flights and at a less definitely marked but much lower elevation in the case of the noon flights. The effect was larger at noon than at 6:00 a. m.

Dines (7) made a similar study about the same time of the insolation effect on the Dines (7a) meteorograph, using a different method entirely than that used in the above study. The time of his day flights corresponded closely to the time of the Weather Bureau's 6:00 a. m. Polar Year observations and the two sets of results were almost identical. Both investigators reached the same conclusion regarding the mechanism by which the effect was produced, namely, the direct absorption by the temperature element itself of solar radiation after multiple reflection in the ventilating tube. These instruments are constructed similarly in this respect. The point of difference in the two investigations was that, as mentioned above, the results obtained by Ballard indicated a larger insolation effect near noon than near 6:00 a. m., while Dines saw no indication that the effect on the Dines meteorograph had a diurnal variation.

During the spring and early summer of 1933 Jaumotte (8) obtained a number of records up to high levels which showed large inversions beginning some distance above the tropopause. Mainly from a study of ascent and descent records and critical data regarding the physical characteristics of the Jaumotte meteorograph he was able to show that the errors in the recorded temperatures caused by insolation were negligible even at very high levels, i. e., 26 km. or so. Jaumotte has since (10) extended his work and still concludes that there is no important insolation effect in the records obtained by him with his meteorograph. His conclusions are arrived at somewhat indirectly, though, instead of by observation and, hence, are not entirely convincing. He made a number of night

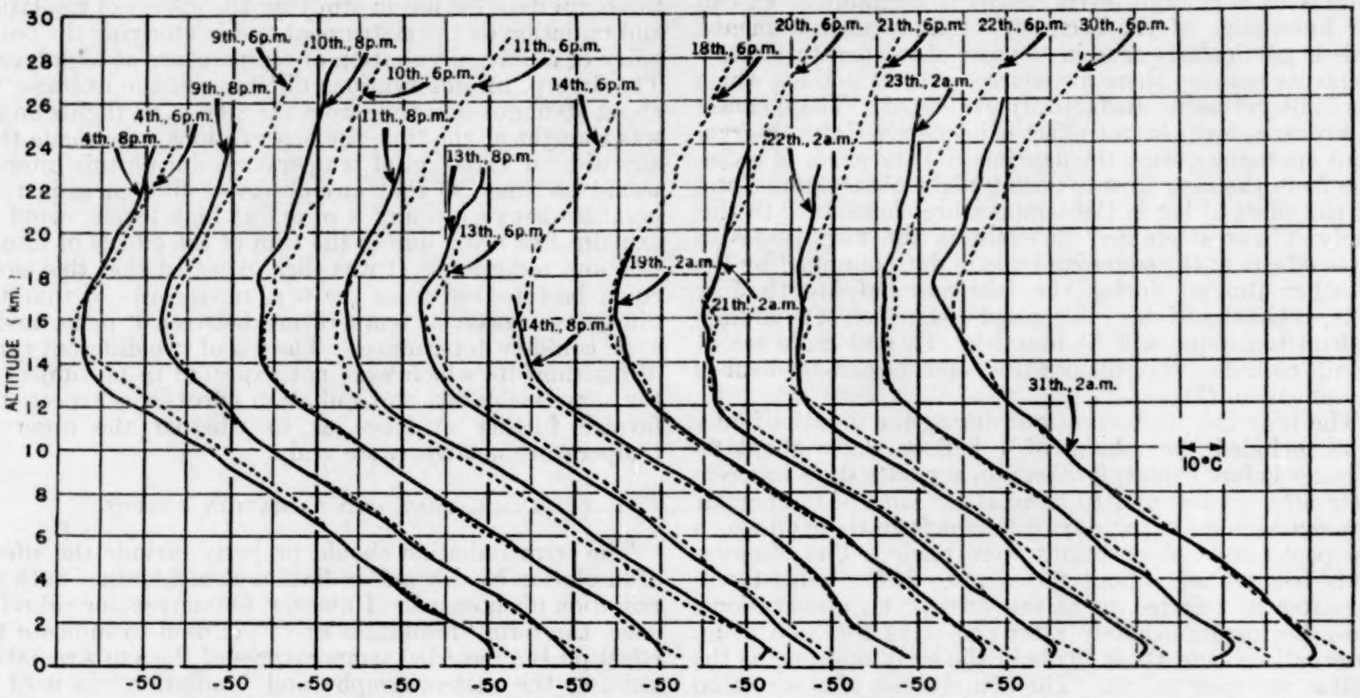

FIGURE 1.—Temperature (abscissa) against height above sea level (ordinate) for dates and times indicated on each curve. The −50° C. abscissa for each date is indicated near the curve for that date. Abscissa lines are 10° C. apart.

flights and in particular made at least one series of observations extending throughout a day and night, this latter to study the diurnal change of temperature. Unfortunately, something happened to the balloon or instrument in nearly every case so that no conclusions could be drawn from the night flights except that the inversion observed was real because the night flights did show an inversion at high levels.

On account of the construction of the Jaumotte meteorograph the effect of insolation could not operate in the same manner on this instrument as it was believed by Dines and by Ballard to operate on the Dines and Fergusson instruments respectively. For this reason and on account of the difference of materials composing the cases of the Jaumotte and Fergusson meteorographs, it would hardly be expected that the effect of insolation on the temperature records of the two instruments would be almost identical unless the effect on each is negligible. It is more or less surprising, therefore, to find that the July 1938 observations show almost identical temperature records to have been made by the two instruments. That is, the temperatures themselves differed, often by 3° or 4° C., presumably on account of errors in calibration, poor base lines, etc., but the magnitudes of the changes were almost the same. To examine the action of each instrument at high elevations, the difference between the minimum temperature recorded on the flight and that recorded at the maximum elevation was obtained for each flight on which both instruments made a good record to the maximum height reached by the balloon. Next, the difference between the magnitude of the inversion recorded by the Fergusson and that recorded by the Jaumotte instruments was found. The average value of this difference was 1° C. for 13 day flights and the same for 5 night flights. It may be safely concluded from this that the effects of insolation and night radiation are either negligible or substantially the same on both instruments.

Figure 1 shows temperature plotted against height for each of the night flights extending well into the stratosphere for which there is a corresponding daylight flight. The daylight flight made just prior to the night flight has been plotted on the same axis as the night flight in each case so that the temperature changes level for level from 6:00 p. m. to either 8:00 p. m. or 2:00 a. m., as the case may be, can be observed directly. It should be noted that both day and night flights indicate, in some cases, layers 5 or 6 km. thick which are substantially isothermal, the day and night flights agreeing in this respect. Now, if the instruments were appreciably affected by insolation, then a recorded isothermal on a daylight flight would mean that the true air temperature was decreasing with increasing height. On account of the relative infrequency of night soundings the effect of radiation from the instrument at night to cause it to record too low temperatures is ordinarily given little consideration. However, there is no obvious reason why this effect should be ruled out. If it is appreciable, then an instrument released at night and recording an isothermal condition would indicate that the true air temperature was rising with increasing elevation. Thus, if two instruments are released, one just before sunset and the other just after, and each records an isothermal condition and it is assumed that no actual temperature change occurs, then it necessarily follows that the respective instruments were not appreciably affected by insolation and radiation up to the height of the top of the isothermal layer. This line of argument indicates that the effects of insolation and radiation were quite small up to the region of 18 km. or so at least in the case of the July observations. Obviously, these two effects are in opposite directions so that any observation of the effect is of the sum of the two effects, and an observation of no effect means that each is negligible.

The above argument did not include the effect of lag alone. In the two cases discussed the effect of lag would be to cause the night instrument to record temperatures which were too low and the day instrument temperatures which were higher than the true values. Since it was concluded that the true lapse rate was isothermal then the effect of lag would be zero.

Above the approximately isothermal layer, and beginning on the average at about 20 km. the temperatures as recorded in available soundings increase with increasing height at the rate of about 2.5° C. per km. for the day flights and somewhat more slowly for the night flights. The effect of lag in this region then is to cause the instruments to record too low temperatures, since the instrument is always colder than the air through which it is passing. The effect of radiation is in the same direction while that of insolation is in the opposite direction. Hence, if all three of these effects were important, it might easily be true that the day-time temperatures were nearer the true values than those recorded at night. The effect of lag should be approximately the same on the day as on the night flights (at least if the lapse rates are not radically different) so that any average differences would be expected to be due to the sum of radiation plus insolation effects or to a diurnal variation of temperature.

VENTILATION

Ventilation of the temperature element, as stated above, is accomplished through the ascent of the instrument. Its magnitude will thus depend upon the rate of ascent, level for level, at high elevations, since the density, level for level, does not in general at any time and place differ by more than 3 percent from a mean value at levels between 20 and 30 km. On the other hand, the rates of ascent may vary between flights by as much as 30 percent. It was thus thought that the temperature changes observed from day to day might be explained as being due partly to changes in the rates of ascent, high temperatures being recorded when the rate of ascent was low and lower temperatures when the rate of ascent was higher. However, no such correlation could be found for the July series of observations. The rate of ascent used during this series averaged about 75 percent greater than that used during the Polar Year so that from this standpoint the July records would be expected to begin to show appreciable insolation effects at higher levels than the Polar Year series.

Figure 2 shows the mean temperature change from 6 p. m. to 8 p. m. and 6 p. m. to 2 a. m. plotted against height, based on all the available flights. The original temperature height curves were smoothed somewhat before the temperature changes were obtained in order to eliminate, insofar as possible, the effects of horizontal differences in temperature on the different flights and small errors in altitudes. It will be noted that the mean changes from 6 p. m. to 8 p. m. and from 6 p. m. to 2 a. m. were about a degree or less at all upper levels between 2 and 16 km. Beginning at 16 km. the daylight flights indicated higher temperatures than the night flights, the differences increasing with altitude. There is some evidence that the average change at high levels is somewhat greater between 6 p. m. and 2. a. m. than it is between 6 p. m. and 8 p. m., which would be expected to be the case if there is a diurnal variation of temperature at these

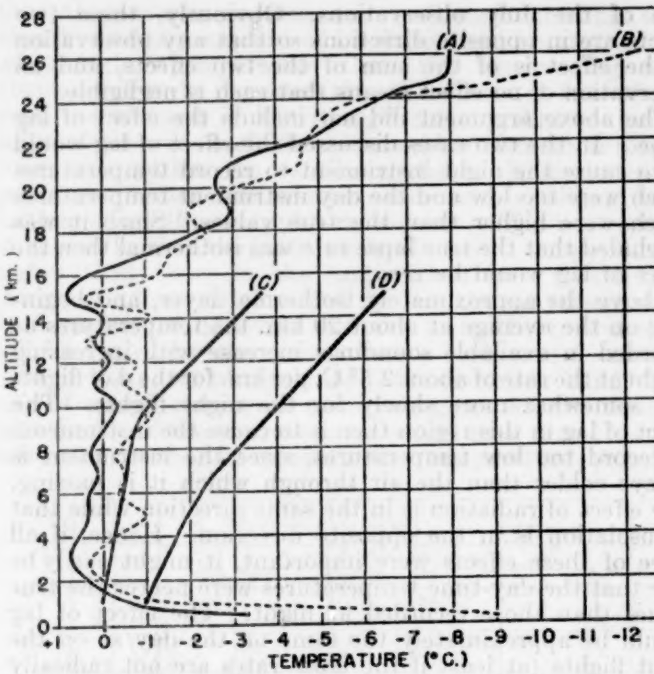

FIGURE 2.—Recorded temperature changes in ° C. against height for: A, July 1938, 6 p. m. to 8 p. m.; B, July 1938, 6 p. m. to 2 a. m.; C and D are Polar Year data reproduced from Mo. Wea. Rev., Feb. 1934, 62: 45-53.

altitudes in phase with that at the ground. The number of observations upon which the means are based, however, is too small for the evidence to be conclusive.

It will also be noted that the shapes of the two curves are quite similar. Since the two sets of data cover different periods it would hardly be expected that the curves would accidently run roughly parallel, changing slope at the same altitudes in a number of cases. Their shapes indicate changing insolation effect, or diurnal temperature variation with altitude. It is not safe to conclude that the changes of slope are real, however, because of the small number of observations. The temperature change from 6 p. m. of the 20th to 2 a. m. of the 21st (see fig. 1) was considerably smaller than on the other days and if this observation were excluded from the data on which the means are based, then the means themselves would be larger for the upper levels. This would support the evidence for a diurnal variation of temperature but the discarding of this observation is hardly justified. It will be shown later, however, that the temperatures at high levels at 6 p. m. on the 20th and 21st were low and rose considerably by 6 p. m. of the 22d.

It might also be argued that the temperatures at 6 p. m. on the 22d and 30th were quite high at 25 and 26 km. and that this accounts for the fact that the values of the falls in temperature from 6 p. m. to 2 a. m. for these levels are larger than the corresponding values for 6 p. m. to 8 p. m. In other words, it appears at first sight that the higher the temperature at 6 p. m. the greater will be its drop during the night, since the range in observed nighttime temperatures at the upper levels is small. This would be the case if there is an important insolation effect which has different magnitudes on different flights. The rate of ascent over the region concerned averaged about 340 meters per minute on the flight of the 22d, practically the same on the 30th and about 320 meters per minute on the flight of the 21st, the day on which the recorded temperature was lower than it was on the 22d and 30th. On the 10th, the single observation upon which the temperature change at 26 km. from 6 p. m. to 8 p. m. is based, the rate of ascent was about 400 meters per minute and the temperature recorded was 2° warmer than on the 21st with a rate of ascent of 320. At 23 km. the recorded temperature on the 10th was 1° warmer than on the 21st and the temperature difference between 8 p. m. of the 10th and 2 a. m. of the 22d was zero. These facts suggest that the insolation effect is independent of the rate of ascent over the range of rates considered up to altitudes of 26 km. or so.

Zistler (9) suggested that the insolation effect on a particular instrument of a given type will depend to some extent on the surface condition; i. e., degree of highness of the polish of the case and radiation shielding. To all outward appearances there was little difference in the surface condition of the meteorographs used in this series of observations and it is not believed that the insolation effect varied appreciably from instrument to instrument on account of this factor. Dines (7) suggested that the radiation reflected from cloud tops may be instrumental in producing insolation effect since if the sun has the proper elevation angle considerable radiation may be reflected vertically upward in a direction from which the temperature elements are not radiation shielded. This factor may vary from flight to flight depending upon the time of day and the cloudiness. It is not believed, however, that this was of appreciable importance in determining the insolation effect during the July series since the observations were made so late in the day.

If we assume for the moment that the insolation effect was substantially constant over the range of ascensional rates used during the July series, then the question arises whether the difference in rates used in this series and that used in the Polar Year series will account for the difference in insolation effect which was found. From the standpoint of elevation of the sun the 6 a. m. observations of the Polar Year are roughly comparable with the 6 p. m. observations of the July series. For convenience of reference the curves shown in figure 1 of (6) have been added to figure 2 of the present paper. These curves were originally extrapolated to 20 km. but the reproduction here has been extended to 15 km. only, since the data above 15 km. were extremely few. The means at 16, 17 and 18 km. did not fall smoothly on the curve as originally drawn and the possibility exists that the curves may change shape radically in this region.

The average rate of ascent during the Polar Year was about 220 meters per minute while the average for the July series was about 350. If the curves shown in figure 2 indicate insolation effect due to insufficient ventilation, then the effect begins to be significant at about 10 km. for the Polar Year observations (6 a. m. flights) and at about 16 km. for the July observations. If there is no change in the character of the air flow about the temperature element over the range of rates 220 to 350 meters per minute then the effective ventilation for each rate is proportional to the product of some power of the rate of ascent times some power of the air density. According to Jaumotte (8) the power should probably be three-fourths in both cases. Using this power we find that the effective ventilation during the Polar Year at 10 km. was 40 percent greater than that at 16 km. during the July series. If, as Jaumotte also suggests, we use the three-fourths power of the density and the one-half power of the rate of ascent, then the effective ventilation was about 60 percent greater during the Polar Year. The ventilation on the noon flights of the Polar Year at altitudes with

corresponding amounts of insolation effect was much greater than on the 6 a. m. flights and still larger than that on the flights of the July series. This indicates quite clearly that either the observed differences were not entirely insolation effect or that the method used by Jaumotte (8) and Zistler (9) and others to compute the insolation effect in their records is not applicable to the Fergusson meteorograph.

The method used by these investigators is based on the record made by the meteorograph on the ascent and descent, the rates of change of altitude being much different in the two cases. It is rather difficult to evaluate a Fergusson meteorograph descent record accurately enough to determine the lag coefficient of the temprature element from the ascent and descent records because of the difficulty of synchronization at high rates of change of pressure. A few such records were checked roughly in an effort to find whether there were important and consistent temperature differences between ascent and descent near the tops of the flights. As well as could be determined they were quite small, i. e., apparently not more than one or two degrees. One descent record was evaluated in considerable detail and as accurately as possible. This was the record made on the 28th of July and it was chosen because the record was quite clear, because the temperatures recorded on this flight in the upper levels were higher than on any other flight during the month and because the rate of ascent was somewbat lower than that of any other flight during the month. The results are shown in figure 5 where the ascent and descent temperatures have been plotted against altitude. The rate of ascent on this flight averaged about 290 meters per minute and the rate of descent varied as indicated in the figure. It will be noted that both ascent and descent curves have substantially the same slope and are spread apart in the way in which they should be spread if there is lag in the temperature element. That is, in the inversion the ascent temperatures are lower than the descent temperatures, while in the region in which the temperature was decreasing with increasing height the reverse is true. It is very interesting to note that the effect of lag alone seems to predominate—i. e., that the effect of insolation is relatively small. This is evidenced by the fact that the descent curve did not show a sudden drop in temperature just after the descent began to a value below that recorded on the ascent as would be the case if there had been a large insolation effect in the ascent record.

Further evidence that the observed temperature differences were not caused by insolation effect is the fact that with this much slower rate of ascent during the Polar Year the actual temperatures recorded on the few summer flights which reached 20 km. and higher were not substantially, if any, higher than those recorded during the July series. Furthermore, there were flights made during the Polar Year at noon, having this lower rate of ascent, on which the temperature recorded was nearly isothermal for more than 10 km. above the tropopause. These records were obtained during the winter season, however, and the evidence indicates that the upper inversion, if it is a permanent winter feature, begins at a higher altitude in winter than in summer (11).

DIURNAL VARIATION OF TEMPERATURE

The evidence thus favors the interpretation of the observed temperature changes during the Polar Year as actual diurnal changes rather than insolation effect. Dines' contention that the insolation effect should not be substantially greater at noon than at 6 a. m., as well as the evidence just presented regarded the relative independence of the "error" of the rate of ascent, and the agreement between the Fergusson and Jaumotte meteorograph temperature records all support the argument that there is an appreciable diurnal temperature variation at all levels up to 26 km. or higher and that the amplitude of the diurnal variation increases with increasing altitude from 2 or 3 km. upward. The Polar Year and the July data are not strictly comparable because the former are based on flights distributed throughout the year while the July data cover only a short period during which the cloudiness and amount of convection probably differed materially from the normal annual values. Hence, the apparent disagreement between the two sets of data is not necessarily a disagreement in fact, if the differences are true and diurnal.

It has been attempted by several investigators to explain the temperature distribution in the stratosphere by considering a condition of radiative equilibrium between the ground, atmosphere, space, and the sun. Pekeris (12) made a critical survey of the more important theories regarding the heat balance of the atmosphere and it is quite clear that none of the theoretical treatments have successfully explained the observed distribution of temperature at very high levels. In particular, none have explained the inversion of temperature observed to begin shortly above the tropopause.

It is often assumed that the only gas at 20 to 30 km. which is present in important quantities and which absorbs solar radiation in significant amounts is ozone. Two papers (13) and (14) summarize very well the present knowledge of the distribution and absorption qualities of ozone. Obviously, this knowledge is very incomplete but according to Gowan (15) and Penndorf (16) the rate of heating or cooling of the air at levels between 20 and 30 km. due to absorption and emission by ozone is much too slow to account for an appreciable diurnal variation of temperature at these levels. A point which has not been made entirely clear, however, is what happens at sunrise and sunset. Wulf and Deming (17) have shown that the rate at which ozone equilibrium is attained at these levels, under the influence of solar radiation, is extremely rapid, being of the order of minutes. Whether the disturbance of this equilibrium together with the absorption and radiation of other constituents of the atmosphere at these levels can account for a sudden drop of temperature just after sunset at these levels and arise just after sunup is not known by the author of this paper. Nevertheless, it does not appear that the available evidence is conclusively contradictory to the operation of such a process. In this connection it is interesting to note the work of Maris (18) who, apparently basing his assumptions mainly on absorption and radiation by carbon dioxide and water vapor, arrived at the conclusion that a diurnal variation of temperature in these levels does exist. Furthermore, the values,he gives for the magnitude of the variation from day to night in summer agrees reasonably well with the July data shown in fig. 2. His conclusions regarding the difference between a winter day and night are also supported to some extent by the scanty data available.

INTERDIURNAL TEMPERATURE VARIATION

Figure 3 shows temperature plotted against day of the month, from the 6 p. m. observations, for the ground at the time of release of the balloon, and for the standard levels indicated. In addition, the daily maximum surface temperature and the temperature at the level where the vapor pressure was 10 mb. have been plotted. The daily

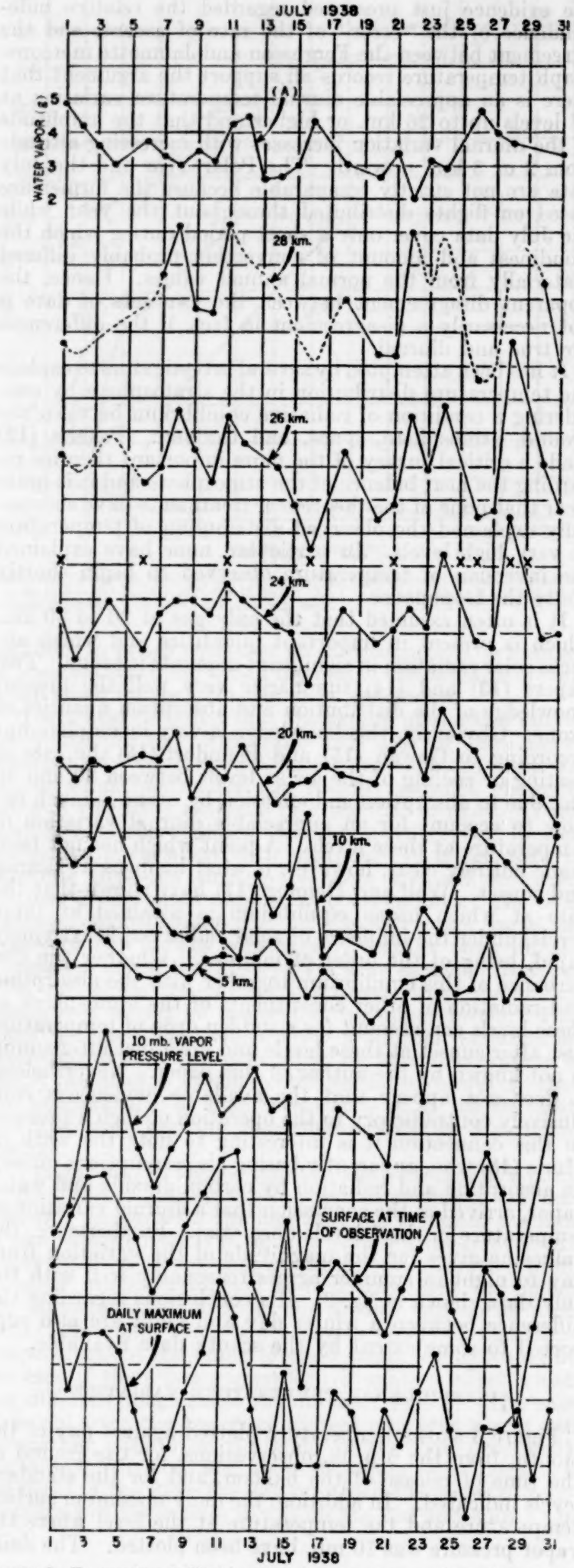

FIGURE 3.—Temperature (ordinate) against date from 6 p. m. observations at levels indicated on each curve. Curve A shows water vapor in grams per unit column 1 square cm. in cross-section from ground to 500 mb. pressure level plotted against date. X between 24 and 26 km. curves indicate cloudiness greater than 5 tenths at time of observation.

maximum temperatures used were those published on the daily Washington weather map. The temperatures at the levels at which the vapor pressure was 10 mb. were obtained directly from the soundings. At the top of the figure the amount of precipitable water in a column one square centimeter in cross section and extending from the ground to a pressure of 500 mb. has likewise been plotted against the day of the month. These values were obtained by integrating the area under the vapor pressure curve between the ground pressure and 500 mb. with a planimeter. In figure 4 the logarithm of the temperature at 24 km. has been plotted against the logarithm of the temperature of the 10 mb. vapor pressure level for all the days during the month for which data were available and on which the amount of cloudiness at the time of release of the balloon was five-tenths or less.

It will be noted from fig. 3 that the day-to-day temperature variations at 5 km. were relatively small and roughly in the same direction as the surface temperature changes. Below this level the day-to-day changes were larger as was also the case for levels higher than 5 km. The day-to-day changes in the troposphere above 5 km. reached a maximum value in the region of 10 km., at which level, as would be expected, they were opposite in sign, in general, to the surface changes. The day-to-day changes again reached a minimum value in the neighborhood of 20 km. and above this level they increased in magnitude with increasing altitude, and, in general, the sign of the change corresponded to that of the surface temperature. At 24 km. and higher the daily variations agreed about as well with the daily surface maximum as with the surface temperature at the time of the flight. It was attempted to correlate the daily variations at 24 and 26 km. with some temperature at a lower level because the solar radiation at these high levels varies little from day to day at a given time of day. The reason for choosing a level of constant vapor pressure was that, on account of the relative uniformity in shape of the vapor pressure curves during the series, it appears likely that some such surface will constitute some sort of effective radiating surface. The value 10 mb. was purely arbitrary.

The data support this idea to some extent as will be apparent upon inspection of the curves. When the curve of total amount of water vapor in the lower levels is considered along with the amount of cloudiness, the evidence is still better that the temperatures and the temperature changes at the high levels are real and are radiative equilibrium values of some sort. The days on which the amount of the sky covered with clouds at the time of the observation was six-tenths or more have been indicated with an "X" between the curves for 24 and 26 km., except when the clouds were very thin cirrus or cirrostratus through which the balloon could be seen with the unaided eye. It would not be expected that there would be a simple relation between the temperatures at high levels and those at low levels, as a result of radiation exchange, when there is a widespread heavy layer of clouds at intermediate levels. The top of this cloud layer would in this case probably constitute the effective radiating surface. It is not entirely clear just how this would affect the temperature at high levels and it is somewhat instructive to consider the cases of the 16th and 28th of the July series. On those days, respectively, were recorded the lowest and highest temperatures at 24 and 26 km. which were observed at these levels during the month. Both days were cloudy. Lower clouds obscured the sky at the time of the observation on the 16th so that the presence or absence of heavy upper clouds could not be determined. A well-defined cold front passed the station between the morning of the 16th and the morning of the 17th and the surface temperature at the time of the ob-

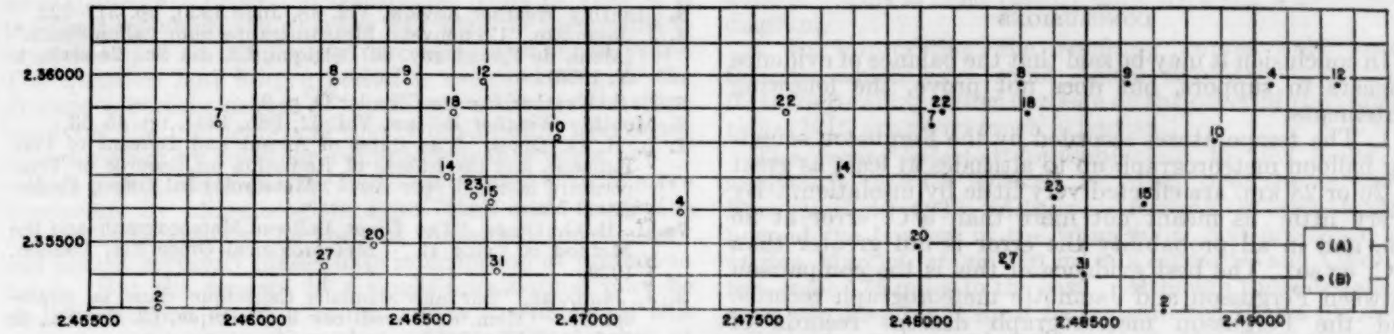

FIGURE 4.—Logarithm of Absolute temperature at 24 km. plotted as ordinate against: (A), logarithm of Absolute temperature at the 10 mb. vapor-pressure level; (B), logarithm of Absolute temperature at ground at time of observation. Numbers refer to the date.

servation on the 16th was quite low. In this case it is quite probable that heavy clouds extended to high levels and that their low upper surface temperature was effective in reducing the temperatures at higher levels. On the 28th eight-tenths of the sky was covered by altostratus clouds. Naturally, the top of this cloud layer had a temperature much lower than any temperature during the month at the 10 mb. vapor pressure level. In fact, the temperature at the top of this cloud layer was probably in the neighborhood of −25° C. At first thought this would appear to indicate that the recorded temperature at the high levels is entirely unreliable. However, it may easily be true that the top of a cloud, which is known to be an excellent radiator (**19**), at this temperature and height and above which there can be little water vapor, is more effective in raising the air temperature at high levels than is a much higher temperature at lower levels operating through a blanket of water vapor. This line of reasoning as applied to the two cases of the 16th when the temperature was low at high levels and to the 28th when the temperature was high may appear inconsistent. However, it should be kept in mind that we know nothing about the existence of high clouds and the distribution of water vapor above the lower clouds in the somewhat complicated situation on the 16th.

In fig. 4 it will be seen that the scatter of the points in the graph of temperature at 24 km. against that at the 10 mb. vapor pressure level is somewhat less than in the graph of temperature at 24 km. against surface temperature at the time of the observation. It was thought that if the air at 24 km. was in radiative equilibrium with the lower levels its temperature might be found to vary as the third or fourth power, roughly, of the temperature at one of these lower levels. In this case when the logarithms of the temperatures are plotted as in fig. 4 a line of slope 3 or 4 should be the curve of best fit. Actually, the slopes of the lines of best fit for the two cases in fig. 4 were computed by the method of Least Squares to be zero in each instance. It should be pointed out, however, that the relative humidity records in this set of observations are quite inaccurate, so that the temperatures at the 10 mb. vapor pressure level are equally undeterminable. The amount of water vapor between the ground and the 500 mb. pressure level was considerably above the average on the 2d, 12th, and 27th, and the effect should be to make the temperatures on these days at 24 km. appear too low, if ground radiation is an important factor. The amount of water vapor below the 500 mb. pressure level on the 22d was considerably below the average for the days considered and the temperature recorded on that date, as we would expect from this reasoning, appears high. A better correlation would possibly have been found if a regression equation relating the temperature at 24 km. to both the surface temperature and the water vapor content had been worked out.

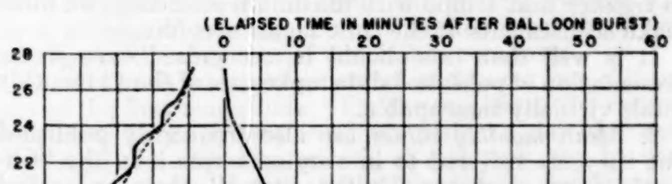

FIGURE 5.—Temperature in ° C. against height above sea level from ascent (solid line) and descent (broken line) records of the 6 p. m. observation on July 28, 1938, and time-altitude curve for the descent.

There can be little doubt about the existence, normally, in summer at least, of this large temperature inversion in the stratosphere. If radiation from the lower layers and the ground is a controlling factor of its cause it is not clear just how it operates. Too little is known about the composition of the atmosphere at say, 24 km. and higher, and too little is known about the absorption and radiation qualities of the gases suspected of being present, to answer the question. It seems entirely possible, however, that there is considerably more water vapor present at high levels than is at present generally assumed to be the case. The amount of water vapor in a given volume could increase quite rapidly at high levels in the inversion and its percentage would then increase still more rapidly with increase in elevation because of the decreasing total density. The temperature might then rise with increasing elevation because of the increasing absorption of outgoing radiation by the increasing water vapor content of the higher layers and its increasing ability to raise the air temperature. That the temperatures at the high levels are controlled to some extent by the ground and lower air layer temperatures is indicated to some extent by winter observations, which show lower temperatures than summer observations at levels well within the stratosphere.

CONCLUSIONS

In conclusion it may be said that the balance of evidence appears to support, but does not prove, the following statements:

1. The temperatures recorded by the Fergusson sounding balloon meteorograph up to altitudes at least as great as 26 or 28 km. are effected very little by insolation. By "very little" is meant not more than 5°C. error at 26 km. and in all probability the error is not greater than 1°C. or so. The best evidence of this is the comparison between Fergusson and Jaumotte meteorograph records, and the Fergusson meteorograph descent records of which figure 5 is an example.

2. Since the effect of insolation is small there must be an appreciable diurnal variation of temperature at all levels up to at least 26 km.

3. The day to day temperature changes at 24 km., or so, and higher are in the same direction as the changes at the ground on clear days. This is probably made possible by a changing composition with elevation in the upper levels.

4. On account of lag the recorded temperatures in the high level inversion may actually be lower than the true values instead of too high.

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THE DUAL RAINFALL REGIME OF ROSWELL, NEW MEXICO

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INTRODUCTION

Current methods of studying the seasonal incidence of rainfall at any particular station are practically all based upon the fundamental assumption that there exists at that station some sort of normal regime of which each annual record is a variant. Though it may be conceded that such variations are of great magnitude, they are usually regarded as wholly fortuitous in character and are expected to cancel each other out in the long run. A record for some 35 consecutive years is usually regarded as sufficient to effect this process, and indeed, in many parts of the world, climatologists count themselves fortunate if the body of data at their disposal is not considerably less comprehensive than this.

Strictly speaking, the distinction between record and normal should be threefold, for we ought not to confuse the normal-as-calculated with the true normal which is no more than a hypothesis. Let us briefly review each of these aspects to make sure that their essential character is not misunderstood.

1. The *annual record* in the case of precipitation data is usually presented as a series of 12 monthly totals. The employment of arbitrary and unequal calendar months instead of more uniform intervals, such as lunar months, is certainly to be regretted but to make a change now would necessitate the conversion of all past records, a thankless and, in many cases, impossible task. The important point is that daily records, even when available, *must* be grouped together to include a considerable time-span before any signs of the emergence of a regime will become apparent. The imperative nature of this consideration is often overlooked although it is no more than an expression of our daily experience of the weather. Evidence exists that in monsoon lands the necessary period should be more than a week, in Great Britain and New England it is probable that even the calendar month is scarcely adequate for the purpose. There is no mystery about this, it is simply a reflection of the fact that in tropical lands the weather may be expected to take some anticipated course with a greater degree of punctuality than is the case in more temperate latitudes. If we wish to register that tempo with maximum efficiency, we must make adjustments of the time factor accordingly.

It is well that this should be recognised even if the presentation of published data makes use of the 12 monthly totals virtually inescapable.

2. *Mean monthly values* are also frequently published but they are referred to in varying terms. In the "Climatic Survey of the United States" they are called "averages"; in "World Weather Records" they are known as "means"; whilst in publications of the British Meteorological Office they become "normals." In view of the fact that all of these are computed by the same identical method of striking an arithmetical average, this diversity of expression is unfortunate. In the rest of this paper the term "average" alone will be used in this connection.

Elsewhere it has been shown that published averages are not always the best descriptive means for use in connection with rainfall data (1). Reasons have been given for regarding median values as a closer approximation to normality. But, although some acquaintance with that discussion is necessary to an understanding of the methods of analysis which follow, the present argument does not hinge upon this distinction.

3. Whilst the record is the direct product of observation and the mean is the tool of the practical climatologist, the *true normal* is no more than an hypothesis, a

mental image. From the traditional point of view it is the *limit* to which the average will tend as the record is extended over an indefinitely increasing number of years. The question how long a period is required to give the average a certain degree of working validity is thus one involving the mathematical theory of sampling and is not solved merely by covering a single Brückner cycle.

This aspect of the matter has been viewed with relative unconcern by climatologists since they are compelled willy-nilly to employ the body of somewhat fragmentary and almost certainly inadequate information at present to hand. But the concept of a single true normal may be challenged upon another count. It is the object of this paper to attempt to show that, in transitional areas at least, there may be two alternative normals. If this is true,the use of a single series of mean values represents the arithmetical fusion of two tendencies which actually remain distinct in nature.

The test case is that of Roswell, N. Mex., where it has been shown in an earlier paper (1) that the rainfall regime is transitional in character between the two striking types experienced on the Plateau of New Mexico in the west and in the Plains of Texas in the east. Our object is thus to demonstrate that at Roswell itself, these two regimes *alternate but do not fuse*. If a prima facie case is made out in favor of this view, the matter is unlikely to rest there. Climatic transitions are found all over the world and elaboration and development of the present method may help us to attain a deeper perception of climatic facts in many unexpected places.

SELECTION OF YEARS

The problem that poses itself is how to disentangel the two themes which are regarded as running through such a record. How can we separate out the "Plains" from the "Plateau" years at Roswell? If the record could be resolved into *two* means it might be possible to carry conviction but any attempt to split it for this purpose really involves a complete reversal of the usual roles played by record and average. Hitherto the average has been employed to eliminate chance variations; it has been a yardstick against which "departures" of the actual record have been assessed. It is now suggested that the record should be used to check the general average and by a process of selection from it we hope to reduce that average to the elements of which it is composed.

Clearly such an approach must encounter two difficulties of the first magnitude. On the one hand, the records for individual years vary so widely with the play of chance that rigid and objective criteria of selection may be very hard to apply to them; and on the other, the averages for the two groups will certainly bear the stamp of any subjective element of distinction that creeps into the process. Careful safeguards must therefore be devised if truly significant contrasts are to be clearly distinguished from purely accidental differences. Indeed, the method must always be used with the greatest caution but a deliberate selection of years for comparison is unavoidable. The precautions against freak results that have been taken in the following discussion are as follows:

1. Selection of years has been made upon certain definite criteria and care is taken that, in interpreting results, it is not these very features that are employed.
2. Control stations are used to indicate how far that characteristic is itself the result of the selection rather than of any real difference in the nature of the record.
3. In summing up the two groups a measure of the scatter about the mean is consistently employed along with it. This is most rapidly done by using a dispersion diagram.
4. In interpreting the resulting curves only those features which have some logical significance, that is, features recalling either one side or the other of the transitional belt, are given much attention.

The record selected for subjection to this mode of analysis is that for Roswell, N. Mex., over the 44 years from 1895 to 1938, inclusive. Records of this length beyond the borders of the transitional belt are available at San Marcial, about 150 miles westwards, and Crosbyton, some 175 miles to the east. Although these distances seem considerable it must be remembered that a hundred miles does not count for much in the open plains of western America.

Seventy to eighty miles south of these stations lie Carlsbad, Agricultural College, and Big Spring in corresponding locations. (2) San Marcial and Agricultural College were placed in the "Rio Grande Region" in an earlier classification of rainfall types, whilst Crosbyton and Big Spring fell into the "Canadian River Region," but for present purposes it will suffice to refer to the two regimes as the "Plateau" and "Plains" types respectively. A glance at diagrams (*c*) in figures 2, 5, 4, and 7 will make the contrast between these abundantly clear. In the Plateau type the first 6 months of the year are virtually rainless and the rains occur mainly during July, August, and September. In the Plains type the rain period is of 7 months' duration from April to October, inclusive, and over most of this interval there is little to choose between one month and another. Clearly the transition zone between such contrasts should be of particular interest—it is represented by Roswell and Carlsbad. Our object is thus to try and recognise Plains type and Plateau type years at Roswell and to check the distinction by applying it to each of the other five stations.

An obvious first step is to present the Roswell record as an historical sequence. This is done in figure 1 where similar graphs for San Marcial and Crosbyton also appear. To simplify the graphs a little the figures have been plotted as 2-monthly totals, January plus February, March plus April, and so on. This method of grouping should not obscure any important feature of the curves (3).

Viewing each graph as a whole we are first impressed by the range of variation from year to year. Even at San Marcial, where the normal regime seemed extremely clear-cut, the variety of annual forms is astonishing. Although, according to average values, the second half of the year should obtain about three times as much rain as the first, there are actually three cases where the first half of the year is the wetter and in four or five others the position is not far from equality. Our acceptance of the concept of normality is thus based upon the general weight of the evidence during the remaining 36 or 37 years and even in a case as striking as this one, regime is shown to have no high degree of inevitability.

A year-by-year comparison of the three graphs brings out further points of interest. In a few years all swing together—as in 1898, 1902, 1922, 1925, and 1936—sometimes with remarkable precision. On other occasions, fortuitous circumstances seem to be in the ascendant and there is little resemblance between any of them (4). But in the great majority of cases the Roswell curve is similar in outline to but one of the others and the number of instances of each would seem to be roughly equal. This is good evidence of the alternation we are seeking to establish.

A first criterion for the selection of the two groups of

years might therefore be the *general form* of the annual curve. The difficulty here is that this may be dominated by some chance event and if some of the contrasts are due to quite odd and local downpours, who shall say that some of the apparent resemblances have a firmer basis in fact? Besides, the "general form" is a vague conception and is capable of varying interpretation in different hands. We need some more specific definition of form especially when considering the inevitable residue of odd or freak forms, the classification of which may present great difficulty.

Greater precision may be achieved if emphasis is laid upon *key elements* in the form of the regime curve. Thus the Plateau type may be characterised by the vigorous rise from June to July, or from May to July. Similarly the Plains type may be recognised by the rise from March to May. Years displaying either of these features would thus be classified accordingly, regardless of the course of events at other times. This method certainly has a high degree of objectivity and is a logical development of emphasis upon rainfall "breaks" or "discontinuities" but it also encounters difficulties: (1) It uses but a fraction of the information at hand; (2) that fraction contains the very points upon which our subsequent argument is likely to revolve, and may lead to the accusation that results have been induced by the method, instead of having been developed out of it; and (3) we are still much at the mercy of freak variations in the particular months concerned—a position, it is true, which no method will allow us completely to escape.

A third method combining breadth with precision would thus seem preferable. It might well be developed out of the *comparison of half-yearly totals* like that already made in discussing the historical diagram for San Marcial. In this manner the selection is freed in large measure from the difficulties attendant upon monthly variation and yet the comparison of monthly means when the two groups have been summed up is not invalidated. The necessary data for Roswell are given in table 1 along with similar figures for San Marcial and Crosbyton.

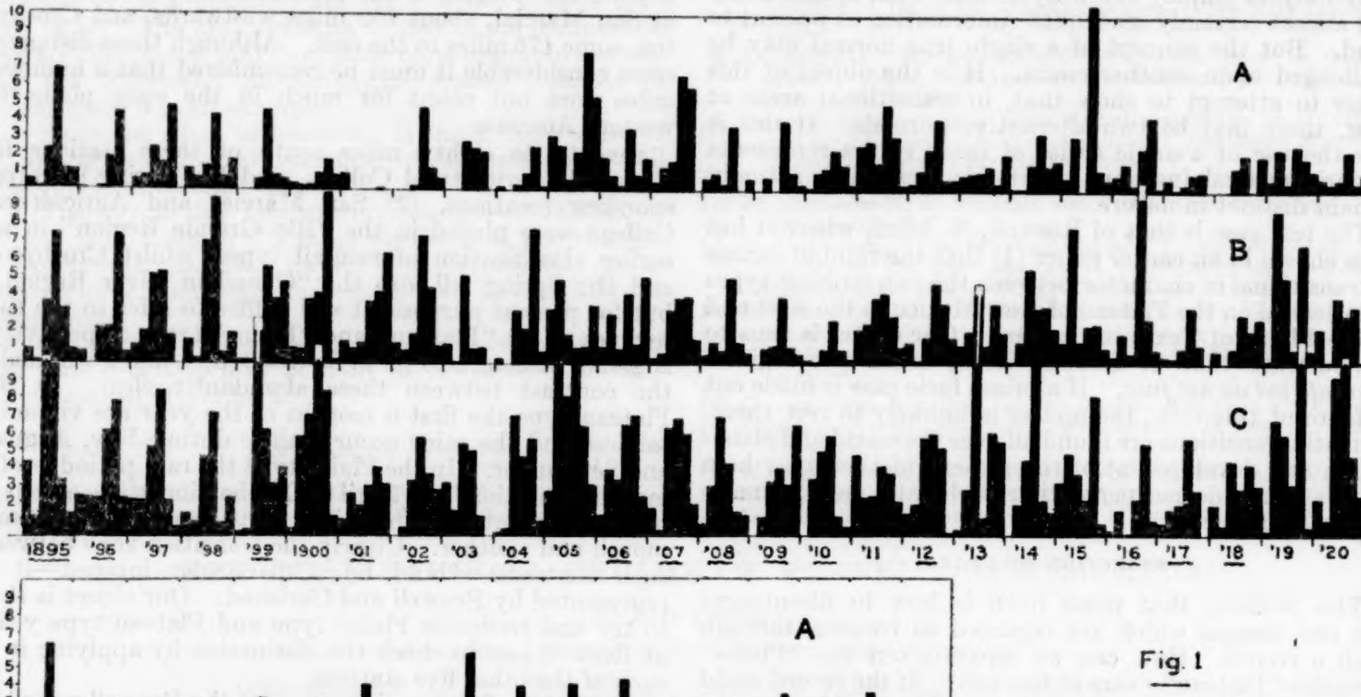

Fig. 1

HISTORICAL RAINFALL DIAGRAMS FOR

A. SAN MARCIAL, N. MEX.

B. ROSWELL, N. MEX.

C. CROSBYTON, TEX.

1895-1938

The actual method of selection employed below has been compound in character but it leans heavily upon table 1. Alternative criteria have been compared and combined to reinforce our case but any one of them taken alone would seem to provide a fairly reasonable basis for distinction.

In the first place, it is argued that Plateau type years at Roswell should have little rain during the first 6 months.

TABLE 1.—*Half-yearly rainfall at San Marcial, Roswell, and Crosbyton*

Year	San Marcial		Roswell		Crosbyton	
	January-June	July-December	January-June	July-December	January-June	July-December
1895	2.92	9.16	4.63	11.51	15.90	14.60
1896	0.19	6.36	2.85	10.27	7.10	16.20
1897	3.77	6.36	8.22	7.01	9.50	11.10
1898	3.32	6.76	8.88	12.08	7.00	10.20
1899	0.72	6.06	2.39	14.17	13.40	13.30
1900	0.88	3.51	5.60	14.20	13.30	20.70
1901	0.93	0.15	3.59	14.55	5.30	10.10
1902	0.27	6.56	3.80	12.78	3.80	12.30
1903	2.90	4.67	6.39	1.78	10.10	6.20
1904	0.50	3.66	3.47	10.58	7.60	11.30
1905	6.26	15.53	9.78	5.45	20.90	19.36
1906	2.95	6.28	4.82	10.39	8.44	15.79
1907	3.46	12.60	4.18	9.25	8.35	14.73
1908	2.10	4.36	2.59	7.03	10.63	6.98
1909	0.81	5.41	2.11	5.58	4.37	13.43
1910	2.57	4.26	1.24	3.63	8.30	7.50
1911	7.15	8.51	8.34	8.03	9.37	9.74
1912	4.06	5.42	3.09	9.81	8.89	11.33
1913	2.94	3.95	7.30	6.47	17.88	12.59
1914	1.83	6.55	6.65	8.80	6.34	13.60
1915	3.91	12.46	10.55	5.62	11.60	11.01
1916	2.86	7.07	2.74	14.08	1.97	8.41
1917	1.15	2.10	1.71	4.50	4.10	8.40
1918	1.45	4.17	1.70	7.48	6.76	9.81
1919	3.56	5.76	14.08	8.61	12.85	15.05
1920	1.80	3.81	6.09	6.49	12.32	17.51
1921	2.43	8.03	8.46	3.21	7.79	4.96
1922	1.54	1.64	5.48	1.09	12.85	4.20
1923	1.81	5.39	4.85	15.19	13.70	16.86
1924	1.58	4.14	2.05	3.72	6.60	7.37
1925	0.18	5.61	1.18	10.35	5.09	14.54
1926	3.38	6.93	6.37	8.42	11.84	22.12
1927	1.78	7.31	2.31	2.52	7.77	8.93
1928	3.19	2.88	5.01	10.03	8.09	11.95
1929	2.88	8.41	4.74	7.64	8.30	11.11
1930	2.46	5.52	3.95	6.52	4.87	13.68
1931	4.66	6.64	8.16	6.26	6.73	14.61
1932	3.29	6.74	6.39	12.44	15.00	17.66
1933	3.68	4.21	1.83	6.96	5.81	15.71
1934	1.19	4.31	3.03	3.93	5.14	4.70
1935	2.41	5.95	4.88	5.66	13.84	11.53
1936	2.02	3.22	4.30	7.52	5.77	16.12
1937	5.70	4.45	7.79	5.66	10.17	12.69
1938	3.05	4.10	4.37	4.71	12.21	10.12

The *absolute* values in the first columns of table 1 have therefore been surveyed and the twenty-two years when these were least are given in column (1) of table 4. This makes a good provisional classification but its weakness is that it uses but half of the information at hand.

It may well be argued that it is the low *proportion* of the annual rainfall falling during the first 6 months that should be stressed. The relationship is therefore stated as a percentage in table 2 from which the years with lowest values are easily extracted for column (2) of table 4.

TABLE 2.—*Roswell, N. Mex., percentage of annual rainfall falling in first half of year*

	Percent		*Percent*
1895	29	1917	28
1896	22	1918	18
1897	54	1919	62
1898	42	1920	48
1899	14	1921	72
1900	28	1922	83
1901	20	1923	24
1902	23	1924	35
1903	78	1925	10
1904	25	1926	43
1905	51	1927	48
1906	32	1928	33
1907	31	1929	38
1908	27	1930	38
1909	27	1931	56
1910	25	1932	34
1911	51	1933	21
1912	24	1934	43
1913	53	1935	46
1914	43	1936	36
1915	65	1937	58
1916	16	1938	48

Comparing the 2 series of results we now find that they agree in 17 cases and these years at Roswell may be declared provisionally to have had a regime not dissimilar from that of the Plateau type. The question now arises whether or not an attempt should be made to add another 5 years to this group so as to split the record equally. Theoretically it is a moot point, since the vibrations of a fluctuating border will only yield equal frequencies along a narrow central zone which cannot be predetermined. On practical grounds, on the other hand, there is much to be said for equal division, for it simplifies questions regarding the validity of means, the disposal of doubtful cases, and the rebuttal of charges of begging the question. Much will depend upon what judgments may be arrived at regarding the doubtful group.

TABLE 3.—*Roswell, N. Mex., comparison of May–June with July–August rainfalls*

	May-June	July-August	Percent increase		May-June	July-August	Percent increase
1895	3.59	7.44	107	1917	0.97	3.32	243
1896	2.09	2.19	5	1918	0.88	2.87	226
1897	5.18	5.32	3	1919	5.02	0.87	
1898	7.08	9.52	35	1920	3.93	2.88	
1899	1.89	5.58	195	1921	7.07	2.95	
1900	3.75	4.10	9	1922	3.19	0.32	
1901	1.26	3.68	189	1923	1.28	3.37	164
1902	1.73	7.32	323	1924	0.15	2.88	1,820
1903	5.11	0.86		1925	0.70	5.60	700
1904	3.10	2.06		1926	3.04	1.84	
1905	1.79	0.98		1927	2.04	1.67	
1906	0.88	4.13	370	1928	3.45	5.31	54
1907	3.18	3.80	19	1929	3.45	5.55	61
1908	0.75	5.03	570	1930	2.20	2.52	15
1909	1.10	3.95	259	1931	1.63	3.69	126
1910	0.90	2.60	189	1932	3.20	6.58	106
1911	3.83	4.16	9	1933	1.13	4.07	260
1912	1.55	4.74	206	1934	1.69	1.61	
1913	4.20	1.10		1935	3.33	1.74	
1914	5.22	3.30		1936	3.15	1.64	
1915	1.32	2.22	68	1937	4.79	1.27	
1916	0.61	10.60	1,637	1938	1.79	2.04	18

TABLE 4.—*"Plateau type" years at Roswell according to different criteria*

(1)	(2)	(3)	Points	Years used (Group A)
1895	1895	1895	3	1895
1896	*1896*		3	1896
		1898	1	
1899	*1899*	1899	5	1899
	1900		1	
1901	*1901*	1901	4	1901
1902	*1902*	*1902*	5	1902
1904	*1904*		3	1904
	1906	*1906*	3	1906
1907	1907		2	1907
1908	1908	*1908*	5	1908
1909	1909	*1909*	5	1909
1910	1910	1910	4	1910
1912	*1912*	*1912*	5	1912
		1915	1	
1916	*1916*	*1916*	6	1916
1917	1917	*1917*	5	1917
1918	*1918*	*1918*	6	1918
	1923	1923	3	1923
1924	1924	*1924*	5	1924
1925	*1925*	*1925*	6	1925
1927			2	1927
	1928	1928	2	1928
		1929	1	
1930			1	
		1931	1	
	1932	1932	2	1932
1933	*1933*	*1933*	6	1933
1934				
1936				
1938				

NOTE.—In each column the eleven most extreme cases have been *italicized*. In the final assessment each of these is given two points.

A third method of selection has therefore been added. It is based upon a modified interpretation of the concept of the key element of the Plateau regime discussed above, namely, upon the proportionate difference between the fall of July plus August as compared with that of the previous two months. The data are given in table 3 and the resulting group of years appears in column (3) of table 4.

Interpreting this table as a whole we note that fourteen years appear in each of the three columns. These should form the hard core of the Plateau group (Group A). Conversely, thirteen years find no mention in any of the columns and are thus probably the most important element of the Plains group (Group B). The remaining doubtful cases would seem at first to set rather a difficult problem (5) but if years with any two of the three qualifications are accepted in Group A this at once includes 21 instances. A very simple system of weighting suggests that 1927 is the year required to complete the equal division. Weighting, in order to distinguish still more clearly between established and doubtful cases would also be a wise precaution should a student try to correlate our results with those yielded by some other element of climate.

DIAGRAMMATIC PRESENTATION OF THE TWO GROUPS

Selection now being complete, it remains to show that the two groups of years at Roswell have indeed contrasting characteristics of a degree at all comparable with those of the Plateau and Plains regimes we have been discussing. This may be done by striking a series of monthly averages for each group or by plotting both of them on separate dispersion diagrams. Figure 3 represents the results of the latter method.

Interpretation of these diagrams depends upon reasonable probability and is therefore not capable of great precision. The quartile range is never more than a rough index of scattering and its efficacy as a test of significant change is substantially reduced when a record is halved. Nevertheless, the contrasts between diagrams (*a*) and (*b*) are so great that it seems highly improbable that they are no more than two aspects of a basically homogeneous body of data. Our broad methods of selection ought not to debar us from comparing individual months in the two graphs. Notice then that the upper quartile for May in group (*a*) barely reaches the lower quartile for that month in group (*b*). The June-July "break" and the more abrupt May-July contrast, both so characteristic of the Rio Grande region, are thus clearly in evidence in the one diagram and completely absent from the other.

The essence of a diagrammatic method, however, lies in its value for *comparative* purposes. We therefore also present figures 2 and 4 where the same grouping of years has been applied to the data for two stations lying outside the transition zone. Theoretically, the regimes at these stations should have but a single theme and our method of grouping ought not to produce significantly different results. This reasoning finds substantial confirmation in the facts. Subsidiary differences do occur, and may be followed up when the implications of this method are better understood, but the characteristic features of the Plateau regime are found in both diagrams of figure 2 and on neither of those of figure 4. It thus seems reasonably certain that the contrasts between groups (*a*) and (*b*) at Roswell were not primarily due to our methods of selection.

Yet a further test is to apply precisely the same grouping to the records for Agricultural College, Carlsbad, and Big Spring. (See figs. 5–7.) In view of the fact that the selection of years was based upon none of these records, the results cannot be regarded as disappointing. There is the same great contrast between the May values in the two groups at Carlsbad whilst the essentially homogeneous character of the records at Agricultural College and Big Spring is clearly demonstrated.

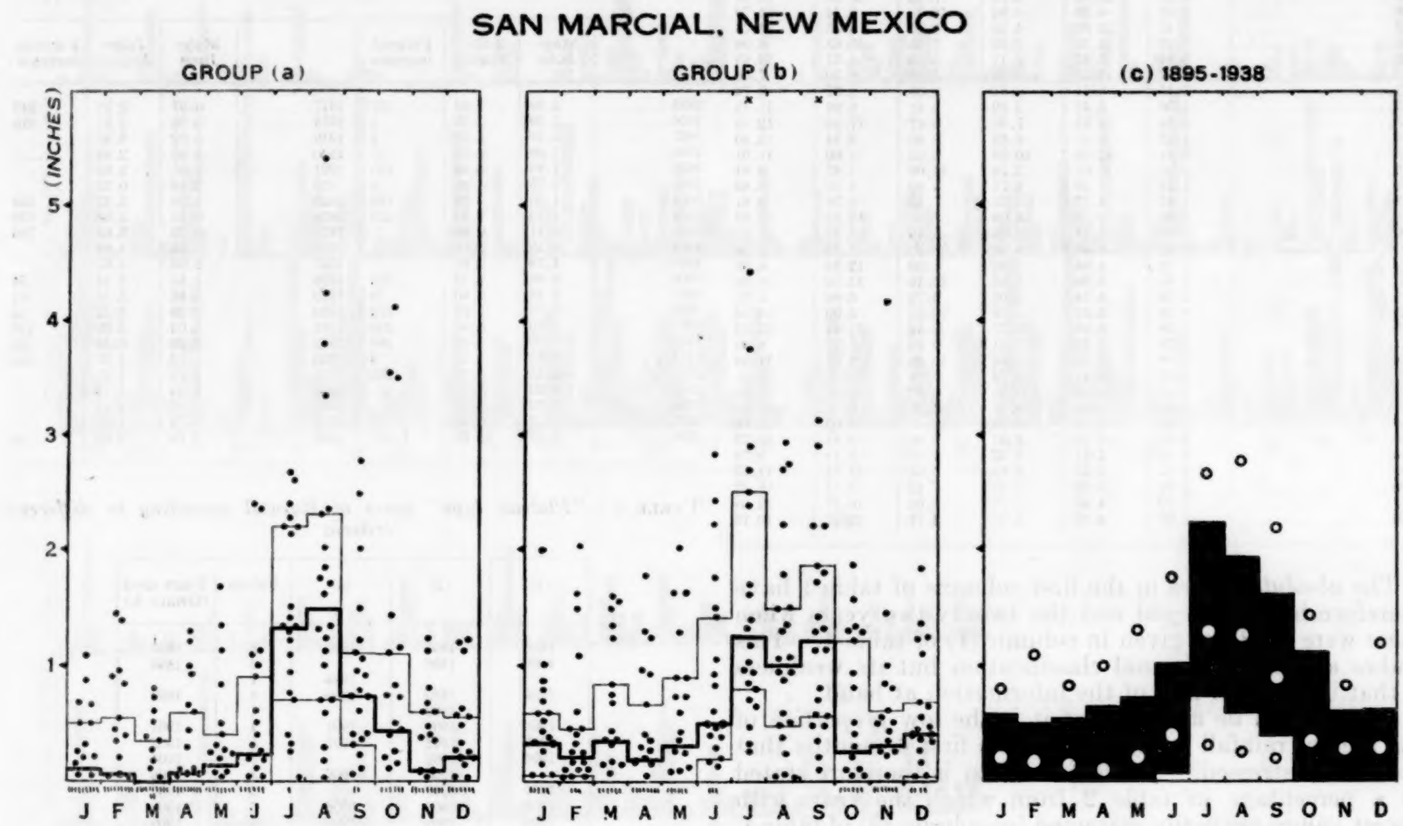

FIGURE 2.

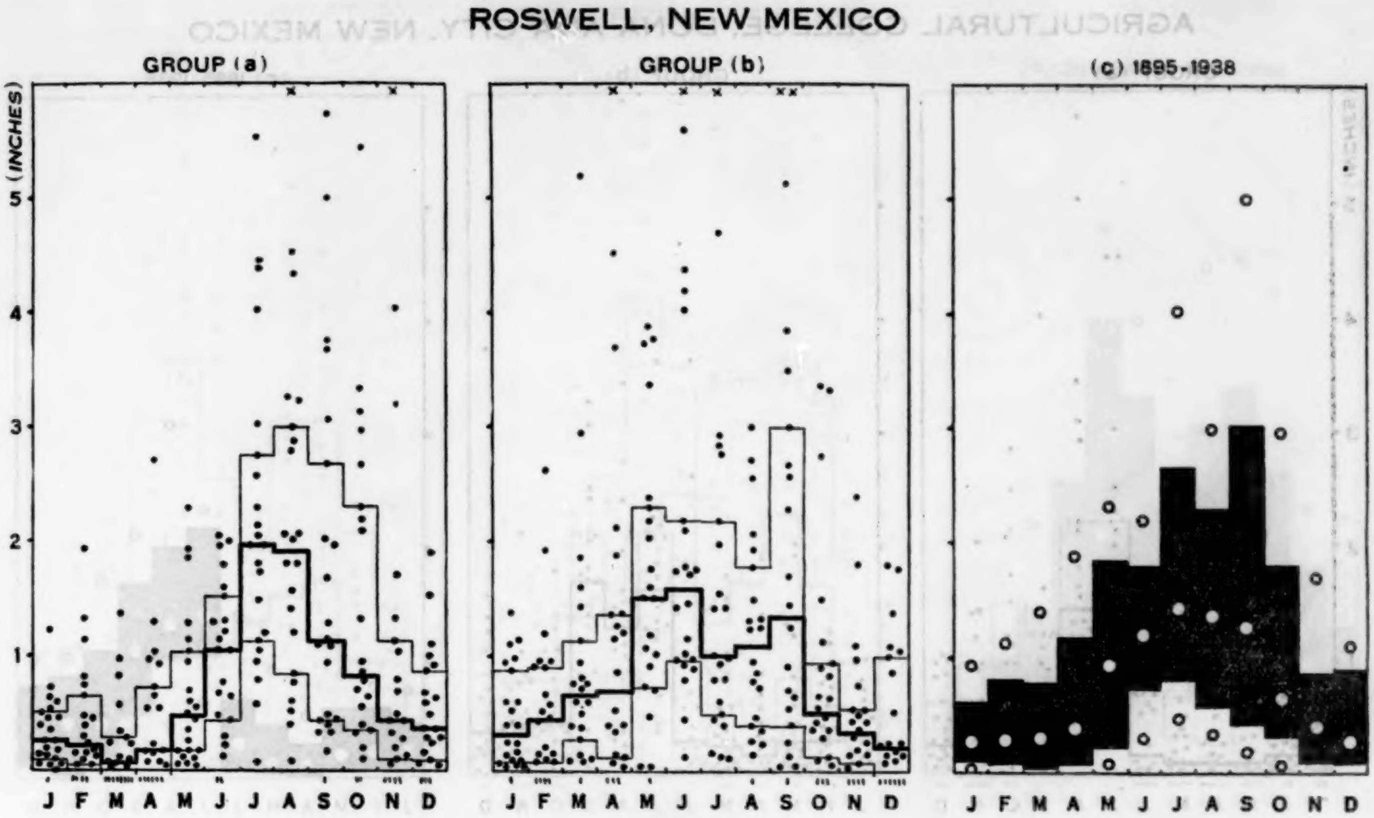

FIGURE 3.

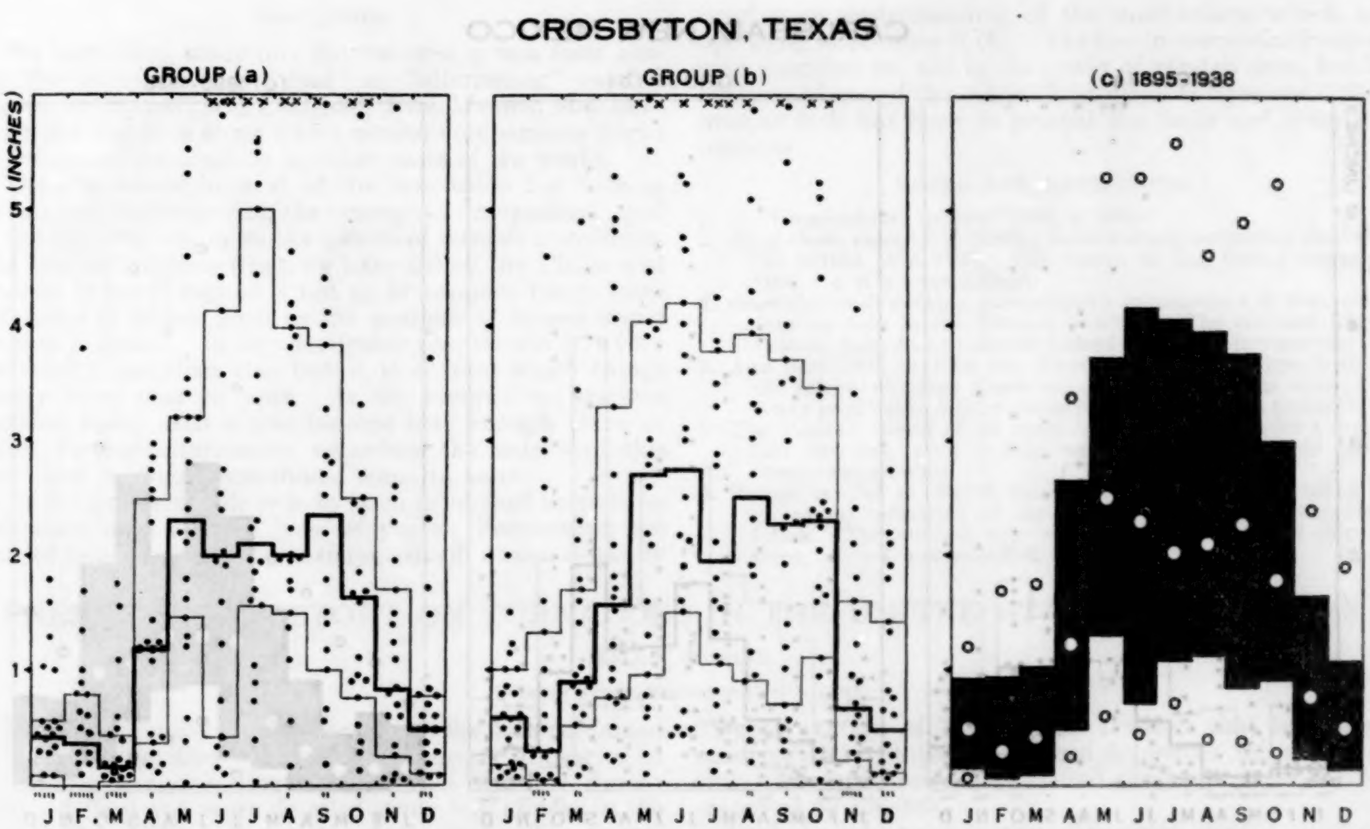

FIGURE 4.

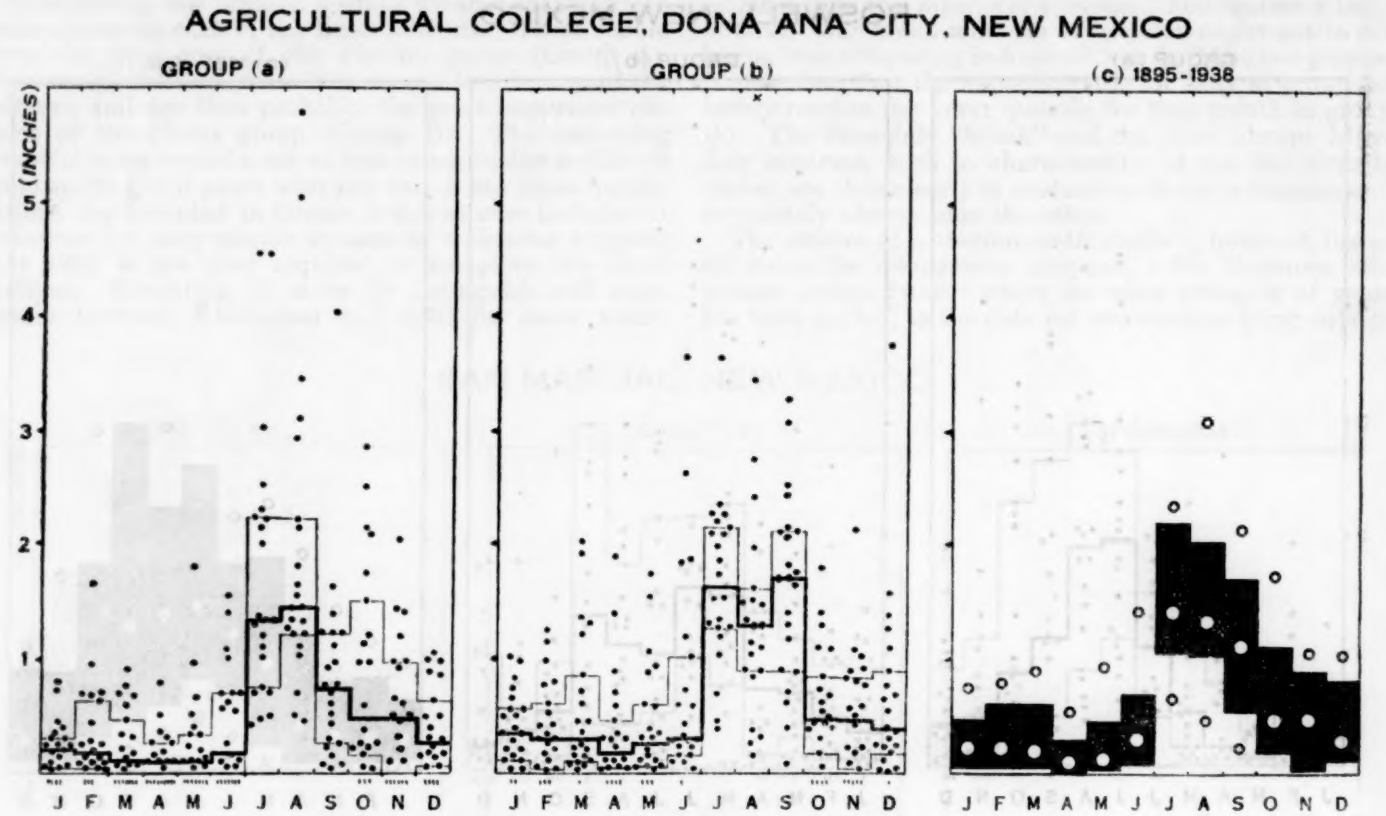

FIGURE 5.

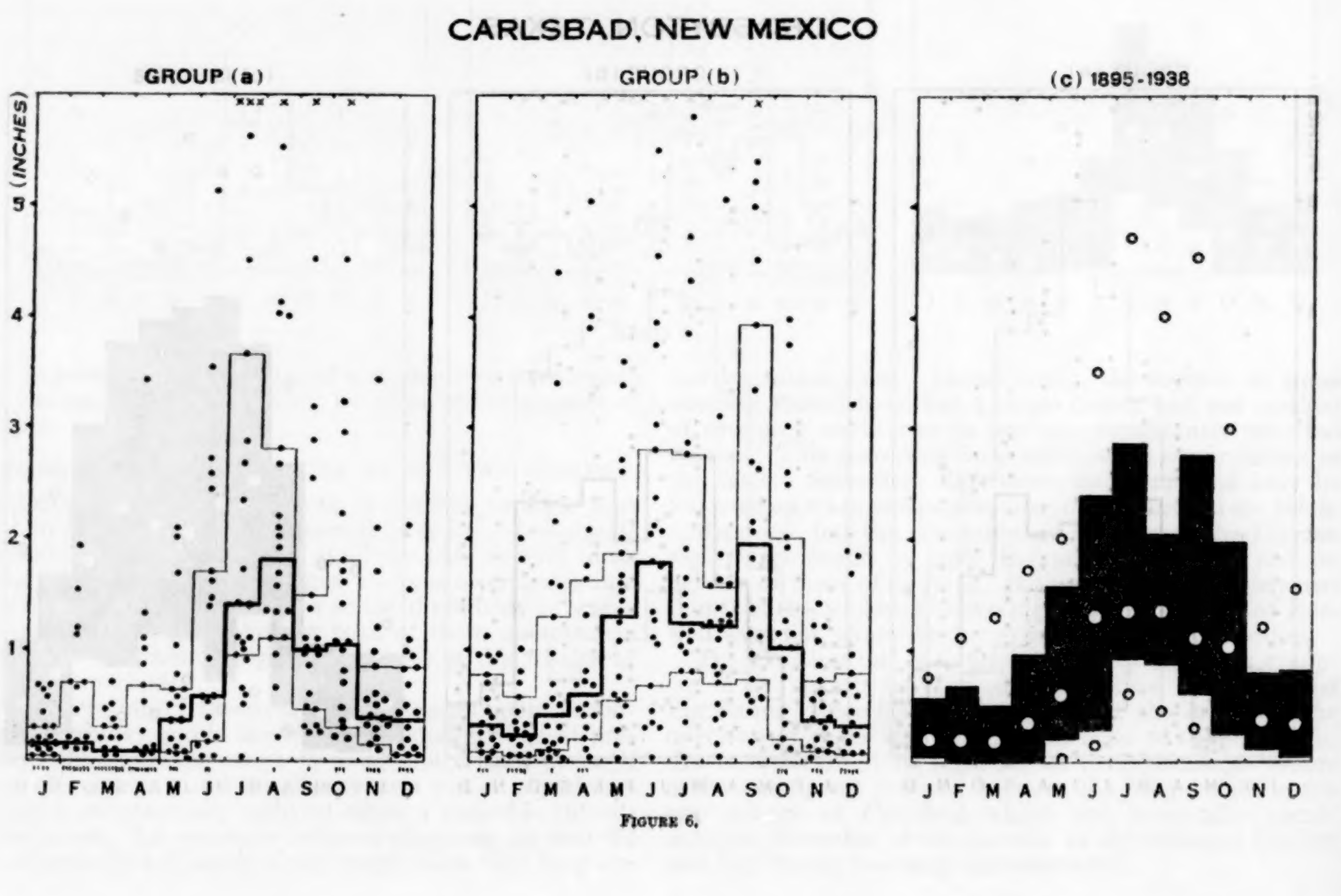

FIGURE 6.

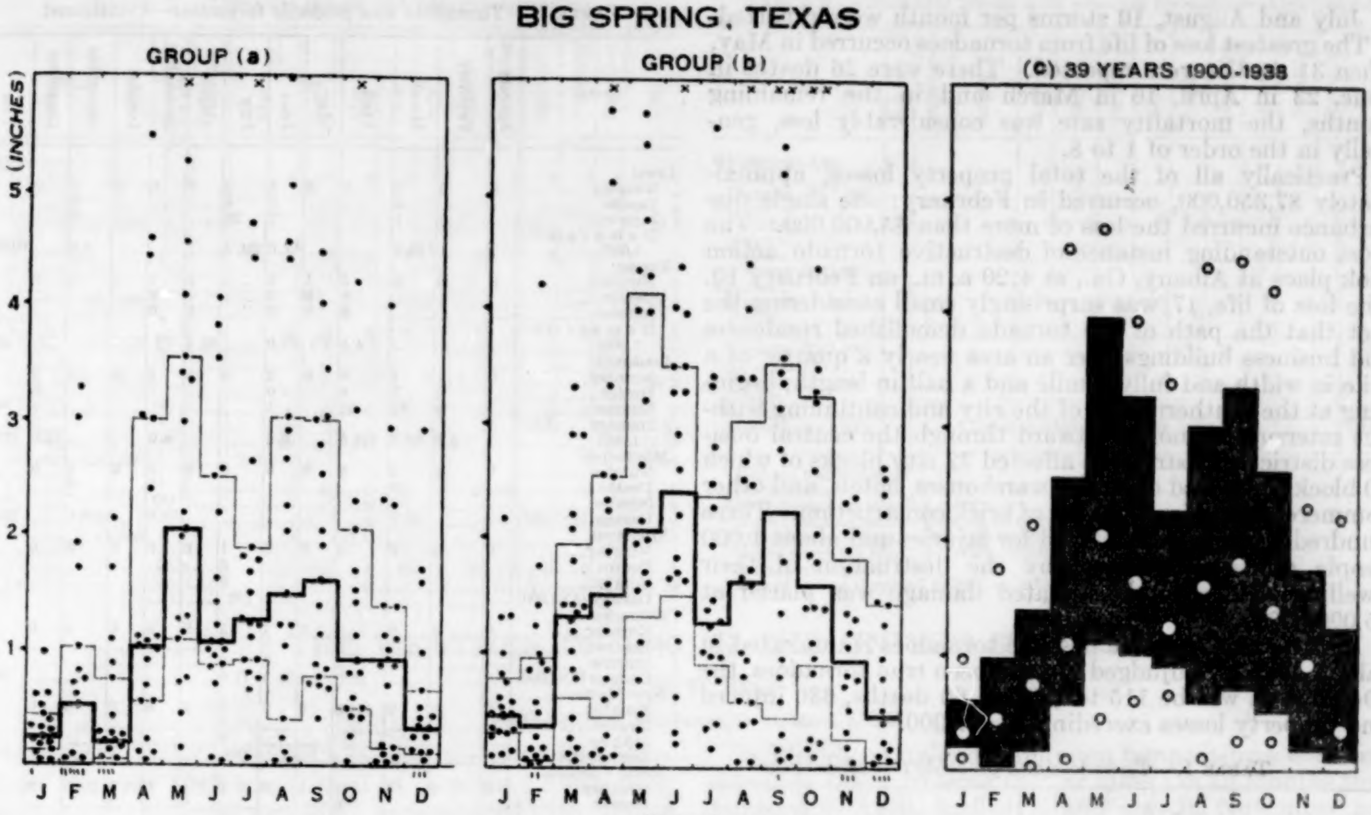

FIGURE 7.

CONCLUSION

We have thus made out the required prima facie case for the existence of a "dual" or "alternating" rainfall regime at Roswell and Carlsbad, New Mexico, and have indicated the lines along which similar comparisons might be instituted for stations in other parts of the world.

The theoretical interest of the conclusion lies both in its implications regarding the concept of "normality," and in the light thrown upon the nature of rainfall transitions. The border between what we have called the Plains and Plateau types of regime is not an amorphous fringe some 250 miles in width, such as the analysis of means would seem to indicate. In any particular year its width is very materially less than this but it is a front which swings widely from year to year. As the records for stations between those used above become long enough to be of value, further information regarding the nature of this front and its migrations should come to hand.

On the practical side it is to be noticed that there is no indication of a regular cycle of years. Forecasting the type of rainfall year to be anticipated will amost certainly involve an understanding of the mechanisms which are operating to produce it (6). The key to successful forecast may therefore lie, not in the study of rainfall data, but in analysis of one of the other climatological elements. Our present task has been to present the facts and state the problem.

NOTES AND REFERENCES

1. In "Geographical Review" 1936, p. 484.
2. All of these, except Big Spring, have records extending over the full period 1895–1938. The record at Big Spring begins in 1900, i. e. it is 5 years short.
3. Since the most striking discontinuity encountered is that from June to July in the Plateau province. The contrast May–June to July–August should indeed be still more vigorous.
4. Also note that in 1916 the Roswell curve differs from both of the others although these are similar one to the other. A heavy local fall in August seems to have caused this anomaly.
5. The Roswell record of 44 years seems rather short for a threefold division, even if this were thought advisable upon theoretical grounds.
6. Except insofar as *March* values at Roswell may be taken as giving an indication of the kind of rainfall year that is to follow. The method may thus hint at unexpected correlations. It will not establish them.

PRELIMINARY REPORT ON TORNADOES IN THE UNITED STATES DURING 1940

By J. P. KOHLER

[Weather Bureau, Washington, March 3, 1941]

The present study is based largely on the data contained in the tables entitled "Severe Local Storms" appearing in the issues of the MONTHLY WEATHER REVIEW during 1940. A final and more detailed study will appear in the *United States Meteorological Yearbook, 1940*. The figures here are substantially correct; however, it must be remembered that all are subject to change after the final study mentioned above.

The frequency of tornadoes during the year 1940 was considerably below normal, namely, 105 as against the 25-year average of 141. Table 1 shows that tornadoes occurred in 24 States, occasioned 50 deaths, injured more than 577 individuals and caused property damage estimated at $7,350,000.

Table 1 enumerates tornado frequency, deaths, injuries, and damage figures by States during the year. An examination of this table shows that the greatest number of tornadoes occurred during the months of March and April, with a total of 42 storms. The month of June ranked second in order, with 14 disturbances; and, in the months

of July and August, 10 storms per month were reported.

The greatest loss of life from tornadoes occurred in May, when 31 deaths were reported. There were 26 deaths in June, 23 in April, 16 in March and in the remaining months, the mortality rate was considerably less, generally in the order of 1 to 8.

Practically all of the total property losses, approximately $7,350,000, occurred in February; one single disturbance incurred the loss of more than $5,000,000. The most outstanding instance of destructive tornado action took place at Albany, Ga., at 4:20 a. m., on February 10. The loss of life, 17, was surprisingly small considering the fact that the path of the tornado demolished residences and business buildings over an area nearly a quarter of a mile in width and fully a mile and a half in length, beginning at the southern edge of the city and continuing without interruption northeastward through the central business district. Destruction affected 32 city blocks of which 10 blocks consisted of stores, warehouses, hotels, and other commercial buildings, mostly of brick construction. Three hundred persons were treated for injuries and about 1,000 people rendered homeless by the destruction of their dwellings. The total estimated damage was placed at $5,000,000.

In the event that the possible tornadoes enumerated in table 2 are later adjudged to have been true tornadoes, the 1940 figures will be 115 tornadoes, 60 deaths, 630 injured and property losses exceeding $9,477,000.

TABLE 1.—*Tornadoes and probably tornadoes*

TABLE 1.—*Tornadoes and probable tornadoes*—Continued

State	January	February	March	April	May	June	July	August	September	October	November	December	Year
Alabama													
Number	1	0	1	1	0	0	0	0	0	0	0	[1] 1	4
Deaths	1		0	0								0	3
Injuries	12		30	0								1	43
Damage ($×1,000)	5.0		20.0	5.0								(14)	[15] 30.0
Arkansas:													
Number	0	0	0	1	1	0	0	0	0	0	0	0	2
Deaths				6	0								6
Injuries				9	0								9
Damage ($×1,000)				8.0	5.0								13.0
California:													
Number	0	0	1	0	0	0	0	0	0	0	0	0	1
Deaths			0										0
Injuries			0										0
Damage ($×1,000)			(2)										(15)
Colorado:													
Number	0	0	0	0	1	0	0	0	0	0	0	0	1
Deaths					0								0
Injuries					0								0
Damage ($×1,000)					(3)								(15)
Florida:													
Number	0	0	0	0	0	0	0	1	0	0	0	5	6
Deaths								0				0	0
Injuries								0				[4] 2	[15] 2
Damage ($×1,000)								1.5				(5)	[15] 1.5
Georgia:													
Number	0	1	0	0	0	0	0	0	0	0	0	0	1
Deaths		17											17
Injuries		[4] 300											[15] 300
Damage ($×1,000)		5,000.0											5,000.0
Idaho:													
Number	0	0	0	1	0	0	0	0	0	0	0	0	1
Deaths				0									0
Injuries				0									0
Damage ($×1,000)				25.0									25.0
Illinois:													
Number	0	0	4	[6] 3	0	0	0	0	0	0	0	0	[15] 7
Deaths			1	2									3
Injuries			8	[7] 20									[15] 28
Damage ($×1,000)			280.0	285.0									565.0
Indiana:													
Number	0	0	2	0	0	0	0	0	0	0	0	0	2
Deaths			1										1
Injuries			24										24
Damage ($×1,000)			160.0										160.0
Iowa:													
Number	0	0	2	0	0	4	2	0	0	0	1	0	9
Deaths			0			0	0				0		0
Injuries			1			1	25				0		27
Damage ($×1,000)			[8] 25.0			[8] 7.0	101.5				3.0		[15] 136.5
Kansas:													
Number	0	0	0	3	1	3		3	1	0	0	0	11
Deaths				0	0	0		0	0				0
Injuries				0	0	0		0	0				0
Damage ($×1,000)				4.0	(9)	[10] 7.0		13.5	(9)				[15] 24.5
Louisiana:													
Number	0	1	4	6	0	2	0	0	1	0	0	2	16
Deaths		0	7	6		0			1			0	14
Injuries		0	62	31		1			(11)			4	[15] 98
Damage ($×1,000)		3.0	60.3	524.8		6.5			6.0			12.0	612.6
Mississippi:													
Number	0	0	3	0	0	0	0	0	2	0	1	0	6
Deaths			0						1		0		1
Injuries			13						(11)		7		[15] 20
Damage ($×1,000)			22.0						33.0		200.0		255.0
Montana:													
Number	0	0	0	0	0	0	1	0	0	0	0	0	1
Deaths							0						0
Injuries							0						0
Damage ($×1,000)							(12)						(15)
Nebraska:													
Number	0	0	0	3	0	3	3	0	0	0	0	0	9
Deaths				0		0	0						0
Injuries				2		0	0						2
Damage ($×1,000)				47.0		24.5	17.0						88.5
New Mexico:													
Number	0	0	0	0	0	0	1	0	0	0	0	0	1
Deaths							0						0
Injuries							0						0
Damage ($×1,000)							(13)						(15)
North Carolina:													
Number	0	0	0	1	0	0	0	1	0	0	0	0	2
Deaths				0				0					0
Injuries				1				0					1
Damage ($×1,000)				(5)				(5)					(15)
Oklahoma:													
Number	0	0	0	0	2	0	0	2	0	1	0	0	5
Deaths					0			0		0			0
Injuries					4			0		1			5
Damage ($×1,000)					25.2			17.2		10.0			52.4
Pennsylvania:													
Number	0	0	0	0	1	0	0	0	0	0	0	0	1
Deaths					0								0
Injuries					1								1
Damage ($×1,000)					(14)								(15)
South Carolina:													
Number	0	0	0	0	1	0	0	1	0	0	0	0	2
Deaths					0			0					0
Injuries					0			0					0
Damage ($×1,000)					3.0			2.0					5.0
South Dakota:													
Number	0	0	0	0	0	0	3	1	0	0	0	0	4
Deaths							0	0					0
Injuries							0	0					0
Damage ($×1,000)							[10] 5.0	53.0					[15] 58.0
Tennessee:													
Number	0	0	1	0	0	0	0	0	0	0	1	0	2
Deaths			0								0		0
Injuries			[4] 15								(11)		(15) 15
Damage ($×1,000)			28.0								160.0		188.0
Texas:													
Number	0	0	3	2	2	0	0	1	0	[1] 1	0	0	9
Deaths			0	3	0			0		0			3
Injuries			0	0	0			0		0			0
Damage ($×1,000)			[8] 25.0	103.5	(5)			0.5		(9)			[15] 129.0
Wisconsin:													
Number	0	0	0	0	0	2	0	0	0	0	0	0	2
Deaths						2							2
Injuries						[4] 3							[15] 3
Damage ($×1,000)						6.0							6.0
United States:													
Number	1	2	21	21	9	14	10	10	4	2	3	8	105
Normal frequency	3	4	16	23	31	26	12	7	8	3	5	3	141
Deaths	3	17	9	17		2			2				50
Injuries	12	300	153	63	5	5	25				7	7	577
Damage ($×1,000)	5.0	5,003.0	620.3	1,002.3	33.2	51.0	123.5	87.7	39.0	10.0	363.0	12.0	7,350.0

[1] From press reports.
[2] No damage reported.
[3] Occurred in sparsely settled region: small damage.
[4] More than this number injured, but no definite figures obtained.
[5] Losses incurred amounting to several thousand dollars, definite estimate not obtained.
[6] No details of one tornado.
[7] Many more received medical attention, but no definite figures obtained.
[8] Additional losses of several hundred dollars, definite estimate not obtained.
[9] Small losses incurred.
[10] Additional losses of several thousand dollars, definite estimate not obtained.
[11] Several injured, definite figures not obtained.
[12] Traversed range land, no property loss.
[13] Occurred in unoccupied area, no property loss.
[14] Losses amounted to several hundred dollars, definite estimate not obtained.
[15] See references in monthly columns.

TABLE 2.—*Tornadic winds and possible tornadoes*

State	January	February	March	April	May	June	July	August	September	October	November	December	Year
Alabama:													
Number	0	1	0	0	0	0	0	0	0	0	0	0	1
Deaths		0											0
Injuries		3											3
Damage ($×1,000)		2.5											2.5
Iowa:													
Number	0	0	0	0	0	0	1	0	0	0	0	0	1
Deaths							0						0
Injuries							0						0
Damage ($×1,000)							12.0						12.0
Kansas:													
Number	0	0	0	1	0	0	[1] 1	1	0	0	0	0	3
Deaths				0			0	0					0
Injuries				0			0	0					0
Damage ($×1,000)				10.0			([2])	3.0					[3] 13.0
Louisiana:													
Number	0	0	1	0	0	0	0	0	0	0	0	0	1
Deaths			10										10
Injuries			[4] 50										[3] 50
Damage ($×1,000)			2,000.0										2,000.0
Michigan:													
Number	0	0	0	0	1	0	0	0	0	0	0	0	1
Deaths					0								0
Injuries					0								0
Damage ($×1,000)					100.0								100.0
Oklahoma:													
Number	0	0	0	0	1	0	0	0	0	0	0	0	1
Deaths					0								0
Oklahoma—Con.													
Injuries					([5])								([3])
Damage ($×1,000)					([6])								([3])
Texas:													
Number	0	0	0	0	0	0	0	0	0	[7] 1	0	0	1
Deaths										0			0
Injuries										0			0
Damage ($×1,000)										([8])			([3])
Virginia:													
Number	0	0	0	0	0	0	0	1	0	0	0	0	1
Deaths								0					0
Injuries								0					0
Damage ($×1,000)								([6])					([3])
United States:													
Number		1	1	1	2		2	2		1			10
Deaths			10										10
Injuries		3	50										53
Damage ($×1,000)		2.5	2,000.0	10.0	100.0		12.0	3.0					2,127.5

[1] Did not reach ground.
[2] No damage.
[3] See references in monthly columns.
[4] More than this number injured, no definite figure obtained.
[5] Several persons inuured, no definite figures obtained.
[6] Losses of several hundred dollars, no definite estimate obtained.
[7] From press reports.
[8] Loss of several thousand dollars, no definite estimate obtained.

THE WEATHER OF 1940 IN THE UNITED STATES

By W. W. REED

[Weather Bureau, Washington, D. C., March 1, 1941]

On the basis of weighted averages for the several sections, the year 1940 was normal as to mean temperature; the value for the year was 53.6°, as compared with a mean of 53.7° for the period 1891 to 1940, inclusive, and the extremes of 55.6° in 1921 and 51.8° in 1917. The largest positive departures from section normal mean annual temperatures (Table 1) were +2.8° in Nevada, +2.4° in Washington and Idaho, and +2.2° in Utah; while the extremes on the negative side were −2.2° in Mississippi, −2.1° in Arkansas and −2.0° in Louisiana.

The monthly extremes of positive anomalies occurred in October with values of +6.8° for North Dakota, +6.7° for South Dakota and +6.6° for Nebraska, while the greatest negative departure came in January as follows: Missouri, −15.2°; Kentucky, −14.7°; Kansas, −14.6°; and Mississippi, −14.5°. This was the coldest January of record in large areas. In Central, Southern, and Eastern States the outstanding abnormal characteristic was the persistence of cold weather with but little variation from day to day, rather than extremely low individual temperature readings. (Weekly Weather and Crop Bulletin, February 6.)

Maximum temperatures of 120° or above were recorded in California, Arizona, and Nevada with highest readings: Greenland Ranch, Inyo County, Calif., 124° on August 11, 123° on July 24, and 122° on June 14; Cow Creek, Inyo County, Calif., 123° on July 24 and August 11, and 122° on June 15; and Parker Reservoir, San Bernardino County, Calif., 121° on August 11. Maximum temperatures of 100° or above were registered in all States outside New England, where the highest reading was 98° at Brockton, Mass., on July 27.

Subzero temperatures were reported from all States except Florida, with minima on January 19, when Fraser, Grand County, Colorado, reported −47° and Bedford, Lincoln County, Wyoming, −45°. The extremes of 124° and −47° registered for 1940 fell well within the range of the record extremes of 134° at Greenland Ranch, Death Valley, Calif., on July 10, 1913, and −66° at Riverside Ranger Station, Yellowstone National Park, Wyoming, on February 9, 1933.

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In Florida, state-wide minimum temperatures were considerably below freezing (27° or lower) in all months from January to April, inclusive, and also in November and December, with the lowest 8° at Mason, Escambia County on January 27. Freezing temperatures were not registered in extreme Southern Florida—minima: Key West, 43°; Tavernier, 36°; Captiva, 34°; and West Palm Beach, 33°.

In general review the outstanding features of temperature distribution were (1) the very extensive area with decidedly subnormal means in January, with the large departures for Missouri and other States already noted, reaching westward to the Plateau Region, (2) the contrast between deficiencies in the East and excesses in the West from March to May, inclusive, and again in September, (3) the wide extent of supernormal averages in February, and June to August, inclusive, and especially in December when negative departures were recorded only from Portland, Maine northwestward, and (4), in marked contrast to all other months except January and April, subnormal means for November in the West with deficiencies averaging more than 4° from Minnesota to Idaho, with an extreme of −6.9° in Montana.

Table 1 and the Chart of Annual Temperature Departures supplement these general remarks.

The average annual precipitation, derived by weighting the averages for the varying areas of the several States, was 30.25 inches or 1.25 inches above the similarly determined mean for the period 1886 to 1940, inclusive, in which the extreme means were 32.74 inches in 1915 and 24.65 inches in 1910.

Figure 1 and table 2 show precipitation at or above normal over all except 14 States from South Dakota to the South Atlantic States, with percentage highest in California (152), next highest in Louisiana (134), and third highest in Idaho, Nevada, Arizona, and Utah (127 to 123). The States with percentage of normal yearly precipitation below 85 were Indiana (83), Missouri (81), South Dakota (79), Illinois (77), and Nebraska (74), two of which, South Dakota and Nebraska, were classified

in 1939 with percentages of 77 and 74, respectively.

The highest annual State averages over 50 inches, of precipitation taken from table 3 are those for Louisiana, 74. 67 (normal 55.83); Mississippi, 60.58 (normal 53.13); and the lowest, less than 15 inches, those for Nevada (11.03) and Wyoming (14.48). The extreme local annual amounts of rainfall were 131.90 inches at Quinault, Wash., and 2.17 inches at Greenland Ranch, Calif.; other comparable heavy annual totals in the West were 128.38 inches at Wishkah Headworks, Grays Harbor County, Wash., and 125.48 inches at Scales, Sierra County, Calif., to which are to be added three highly unusual values from Louisiana;

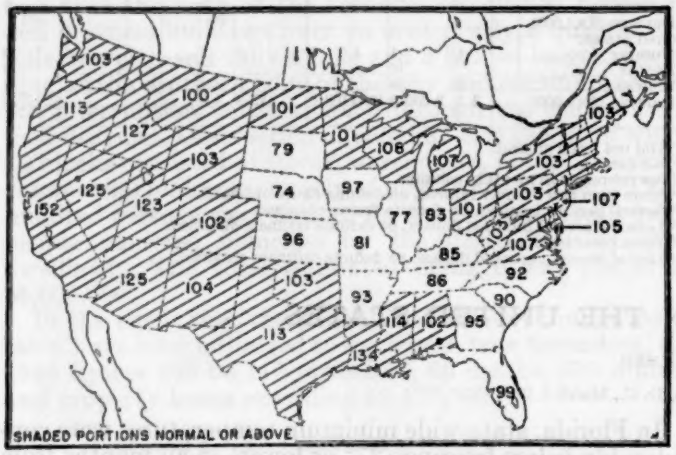


FIGURE 1.—Percent of normal precipitation, 1940.

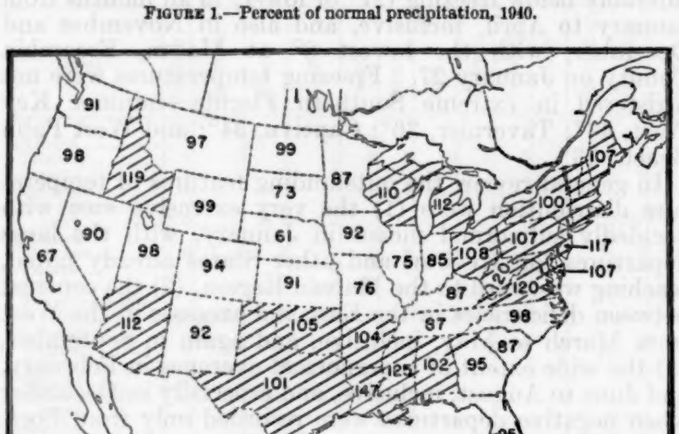


FIGURE 2.—Percent of normal precipitation, April 1—September 30, 1940.

106.64 at Crowley, Acadia Parish; 105.50 at Grand Coteau, St. Landry Parish; and 104.97 at Jennings, Jefferson Davis Parish. Yearly totals under 3 inches were reported also from Thorne, Mineral County, Nev. (2.73) and Cow Creek, Inyo County, Calif. (2.39).

The greatest average monthly falls for section areas (over 10 inches) were 10.83 for Louisiana in August, 10.57 for North Carolina in August, 10.38 for Mississippi in July, and 10.22 for South Carolina in August. In contrast the average 3-month total for June, July, and August in California was only 0.10 inch and the average 2-month total for July and August in Nevada was 0.09 inch.

Local amounts of monthly precipitation in excess of 30 inches occurred in Louisiana in August (maximum 37.99 at Lafayette), in California in January, February, and December (maximum 32.71 at Inskip, Butte County, in February), in Oregon in February (31.42 at Valsetz, Polk County), and in Washington in February (31.11 at Peterson's Ranch, Skamania County). Monthly precipitation of less than a measureable amount of 0.01 inch at one or more stations was reported in all months and instances of this occurred in two out of three States: California had about 250 stations with zero or trace in both July and August.

The greatest 24-hour falls by States, over 15 inches, were 19.76 at Crowley, and 19.63 at Lafayette, Lafayette Parish, La. on August 8–9; 16.05 at Smithville, Bastrop County, Tex. on June 30; and 16.00 at Hempstead, Waller County, Tex., on November 24th.

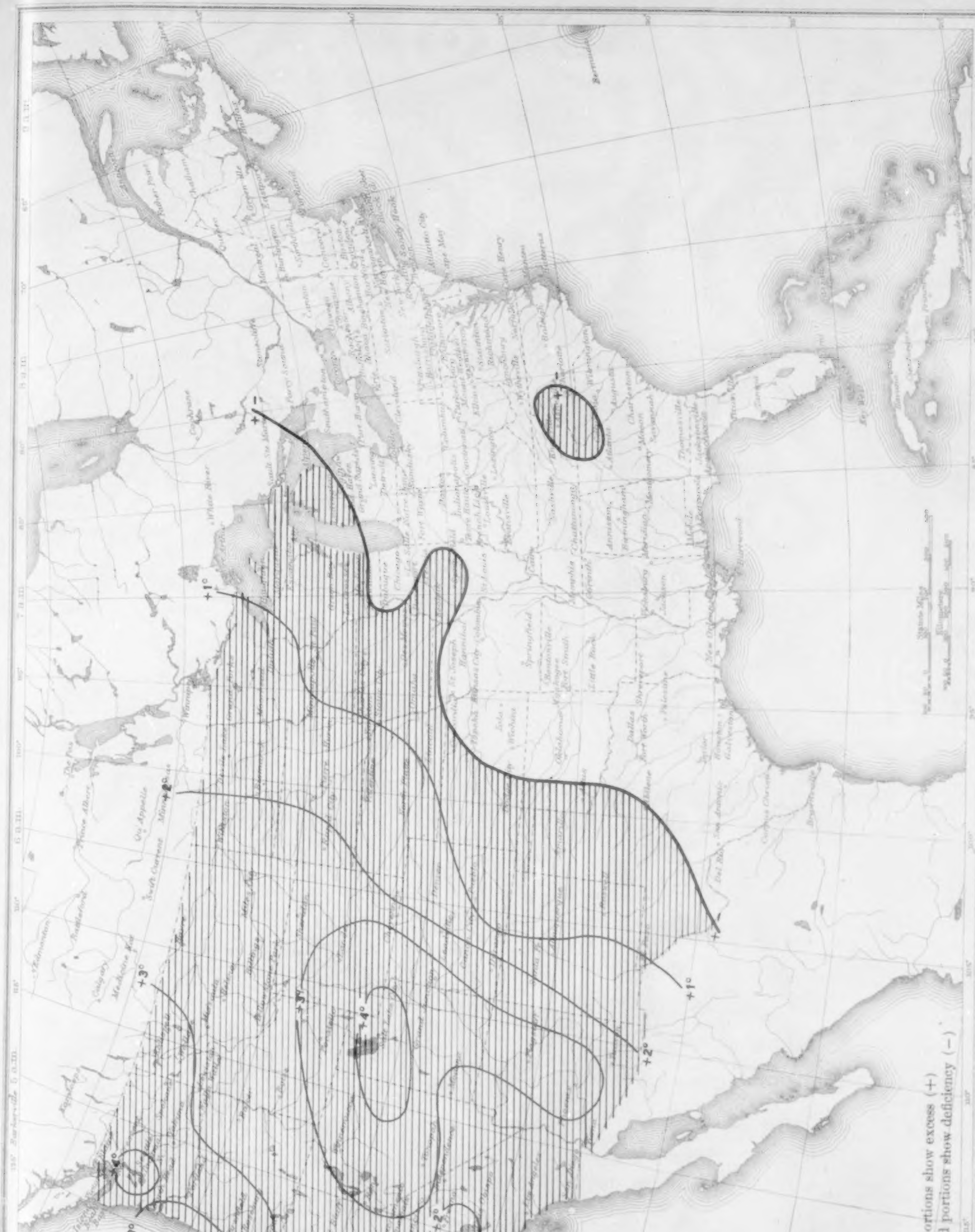
TABLE 1.—*Monthly and Annual Temperature Departures from Normal for the Year 1940*

Section	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Ala.	−12.2	−3.1	−0.6	−1.1	−2.4	−1.0	−1.6	+0.7	−2.0	+1.3	+0.3	+4.3	−1.5
Ariz.	+2.4	.0	+1.9	+.6	+3.4	+2.2	+.6	+.7	−.2	+1.0	−.2	+4.1	+1.2
Ark.	−13.2	−1.7	−.7	−1.5	−2.5	−1.9	−2.1	−2.4	−3.2	+2.5	−2.0	+3.8	−2.1
Calif.	+2.3	+.5	+1.7	+.3	+2.6	+2.6	−2.0	.0	−2.0	+.4	−2.1	+2.7	+0.6
Colo.	−4.2	+1.6	+3.3	+.9	+3.0	+2.8	+2.3	+.6	+2.5	+3.4	−3.0	+2.6	+1.3
Fla.	−9.3	−4.0	−2.2	−2.0	−2.6	+.1	+.1	+1.5	−2.1	−2.2	+.1	+4.4	−1.5
Ga.	−11.9	−2.5	−2.4	−1.7	−2.2	−.2	−1.5	+.4	−2.5	+.1	.0	+3.4	−1.8
Idaho	+2.2	+4.8	+4.2	+1.6	+3.9	+4.2	+1.0	+1.9	+2.2	+2.8	−4.3	+3.7	+2.4
Ill.	−12.6	+1.1	−2.5	−1.3	−2.7	+1.1	+.4	+.7	−1.3	+4.5	−1.9	+5.0	−0.8
Ind.	−12.8	+1.0	−3.1	−2.6	−3.2	+.7	+.2	+1.9	−2.0	+3.7	−1.4	+4.9	−1.1
Iowa	−10.1	+1.9	−3.0	−1.2	−1.7	+1.7	+2.0	−1.4	+1.9	+6.1	−2.7	+4.2	−0.2
Kans.	−14.6	+.8	+1.2	−.4	.0	+.4	+2.6	−1.5	+.7	+6.2	−2.8	+3.4	−0.3
Ky.	−14.7	−1.0	−2.1	−2.0	−3.6	−.7	−1.6	+.2	−3.8	+2.1	−.6	+5.1	−1.9
La.	−12.3	−2.6	−.1	−1.0	−1.8	−1.5	−.9	−1.6	−2.8	+.5	−.1	+3.8	−2.0
Md.-Del.	−11.5	+1.1	−4.4	−4.0	−.7	+1.0	−.2	−2.0	−3.2	−3.0	+.3	+5.0	−1.8
Mich.	−4.1	+2.9	−4.7	−2.8	−1.5	+.1	+1.2	+1.1	+.3	+.9	−1.5	+2.8	−0.4
Minn.	−4.4	+4.8	−4.9	−2.5	−1.0	−.6	+1.6	−1.3	+3.4	+5.1	−4.0	+3.4	0.0
Miss.	−14.5	−3.7	−.5	−1.5	−2.6	−1.7	−2.2	−1.0	−2.6	+.7	−.7	+4.1	−2.2
Mo.	−15.2	+.4	−.9	−1.1	−1.8	−.1	−.3	−.9	−.6	+5.4	−2.1	+4.4	−1.1
Mont.	−5.2	+2.7	+4.7	−1.3	+3.6	+2.9	+2.1	+2.6	+5.9	+4.6	−6.9	+4.7	+1.7
Nebr.	−11.4	+1.7	+1.3	−.9	+.8	+2.3	+4.3	+.2	+4.7	+6.6	−3.6	+3.1	+0.8
Nev.	+4.2	+4.2	+3.3	+1.5	+6.2	+5.5	+.2	+3.1	−.1	+2.9	−2.0	+4.0	+2.8
N. Eng.	−6.3	+1.1	−4.0	−3.6	−.2	−2.4	−.3	−1.6	−1.3	−3.7	−.2	+.4	−1.8
N. J.	−8.5	+1.3	−4.5	−4.1	−.7	−.4	+.1	−2.6	−2.3	−3.6	−.2	+3.2	−1.9
N. Mex.	−2.2	−1.0	+1.4	−.2	+1.5	−.3	+1.3	−.9	+.9	+1.7	−2.5	+3.4	+0.3
N. Y.	−7.8	+.3	−5.8	−3.4	+.4	−.8	−.3	−1.1	−2.0	−3.6	.0	+2.9	−1.8
N. C.	−11.8	−.9	−3.0	−1.6	−1.4	+1.3	−1.0	−.5	−2.9	−.5	+.2	+3.6	−1.5
N. Dak.	−2.8	+5.4	−.7	−3.6	+1.3	+.1	+2.6	+1.3	+5.9	+6.8	−4.6	+6.7	+1.5
Ohio	−11.6	+.4	−3.5	−3.2	−1.9	+1.0	−.4	+1.1	−2.8	+1.3	−.7	+5.7	−0.9
Okla.	−12.8	+.4	+2.2	−.4	−.1	−1.6	−.7	−2.5	−1.4	+4.3	−3.0	+3.1	−1.0
Oreg.	+2.3	+3.4	+3.4	+1.1	+3.5	+4.1	−.2	+1.6	+1.1	+2.5	−3.3	+2.3	+1.8
Pa.	−9.1	+1.0	−5.2	−3.4	−.3	−.3	+.1	−1.5	−2.8	−2.5	.0	+4.6	−1.6
S. C.	−11.5	−1.8	−3.2	−1.6	−2.5	+.9	−.2	−.4	−2.0	−.1	.0	+3.0	−1.6
S. Dak.	−9.1	+2.0	−1.4	−2.5	+1.0	+1.6	+4.4	+.2	+5.4	+6.7	−4.8	+5.2	+0.7
Tenn.	−14.3	−1.9	−2.1	−1.5	−3.0	−.4	−1.5	+.4	−2.8	+2.9	−.9	+4.6	−1.7
Tex.	−10.1	−1.2	+1.0	−.9	−.4	−2.7	−.8	−1.4	−1.4	+1.3	−2.3	+2.7	−1.4
Utah	+2.3	+3.2	+3.6	+1.5	+4.9	+3.7	+1.9	+2.8	+1.0	+2.5	−3.3	+2.6	+2.2
Va.	−11.5	−.1	−3.5	−2.2	−.7	+1.2	−1.2	−1.3	−3.4	−1.2	+.5	+4.6	−1.6
Wash.	+3.5	+3.8	+4.0	+2.0	+3.7	+3.4	+.9	+1.0	+4.6	+3.2	−3.9	+2.9	+2.4
W. Va.	−12.1	+.1	−3.7	−2.5	−1.6	+.6	−.6	−.4	−4.2	−.3	.0	+5.7	−1.6
Wis.	−5.3	+4.1	−5.4	−2.6	−2.6	−.5	+.8	−.7	+1.0	+2.7	−2.3	+2.4	−0.7
Wyo.	−4.3	+2.8	+4.4	−.5	+3.0	+3.0	+2.8	+2.0	+4.3	+4.0	−4.9	+3.4	+1.8

If high degree of raininess may be determined by the large area of sections in which precipitation was 50 percent or more above the normal, then in 1940 the wettest months were February, April, and November, and if abnormal dryness is to be related, on the other hand, to the area of the sections with State averages of precipitation below 60 percent of the normal, the driest months were January, May, July, September, and October. The highest monthly percentages of normal fall from table 2 are 335 in Idaho, 276 in Nevada, and 272 in Utah, all in September; and the lowest are 3 in Nevada in July, and 10 in California and Oregon in August. Such contrasts as those just given are found, of course, only in regions that are arid or have the wide ranges in monthly rainfall typical of the Mediterranean type of climate found on the western coast.

Percentages of normal rainfall inches, 303 in April, 201 in June, 214 in August, and 212 in November in Louisiana; and 210 in Oregon and 201 in California in February, have a background such that they really denote unusual raininess both relatively and actually.

Annual Temperature Departures (°F.) in the United States, 1940



Annual Precipitation Departures (inches) in the United States, 1940

Shaded portions show excess (+)
Unshaded portions show deficiency (−)

TABLE 2.—*Percentage of Normal Precipitation, 1940*

Section	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Ala	89	131	89	83	88	149	156	65	45	51	107	128	102
Ariz	57	141	21	131	100	257	42	97	242	212	132	311	125
Ark	36	100	50	142	71	106	110	136	54	61	160	91	93
Calif	174	201	120	78	64	25	14	10	87	143	57	250	152
Colo	187	131	98	87	91	56	75	73	211	71	126	123	102
Fla	95	149	114	97	49	103	115	102	99	20	55	209	99
Ga	108	110	83	84	62	106	117	137	28	33	138	98	95
Idaho	118	214	136	159	33	60	123	17	335	157	100	88	127
Ill	64	75	66	120	78	71	47	120	18	78	105	91	77
Ind	54	107	50	159	102	81	44	81	34	82	117	83	83
Iowa	78	109	99	118	51	77	122	182	25	97	153	114	97
Kans	124	92	91	115	100	67	49	138	89	53	203	120	96
Ky	38	133	107	123	87	81	65	96	67	27	107	80	85
La	61	155	71	203	41	201	122	214	96	39	212	165	134
Md.-Del	69	94	114	162	133	53	77	125	102	81	195	79	105
Mich	121	79	67	77	123	143	67	195	73	96	130	104	107
Minn	35	111	162	126	60	90	80	142	35	141	221	95	101
Miss	62	128	78	144	58	146	206	90	78	47	155	142	114
Mo	61	80	77	114	51	90	42	148	17	60	133	126	81
Mont	70	188	102	197	56	82	119	26	140	128	112	47	100
Nebr	131	83	144	91	30	75	52	67	57	93	136	133	74
Nev	196	159	94	159	26	84	3	16	276	154	80	175	125
N. Eng	60	101	129	159	138	106	97	49	106	37	171	96	103
N. J	54	84	136	156	169	88	57	125	124	69	147	82	107
N. Mex	105	168	75	74	161	89	61	98	94	61	258	165	104
N. Y	58	116	144	130	109	115	85	71	98	66	125	134	103
N. C	84	86	74	98	91	76	73	191	37	39	159	79	92
N. Dak	21	133	114	152	84	65	148	99	67	147	95	81	101
Ohio	48	123	88	177	122	127	51	124	52	64	126	109	101
Okla	54	162	21	148	82	91	116	112	92	57	232	108	103
Oreg	77	210	132	105	56	25	136	10	237	153	87	89	113
Pa	43	106	142	154	114	98	76	110	99	62	141	97	103
S. C	99	105	87	68	78	72	62	179	34	31	178	76	90
S. Dak	36	109	156	125	20	85	68	98	45	79	100	68	79
Tenn	43	119	107	103	79	95	93	103	35	67	98	72	86
Tex	43	128	53	99	91	176	75	118	48	96	273	170	113
Utah	188	178	89	123	19	79	43	53	272	132	132	157	123
Va	78	85	69	132	117	93	115	213	50	56	176	80	107
Wash	59	199	124	117	78	25	179	49	112	164	76	83	103
W. Va	40	123	94	146	123	137	97	118	98	65	118	69	103
Wis	75	91	71	98	101	162	76	191	34	86	179	106	108
Wyo	153	129	90	158	41	86	92	46	201	89	137	76	103

In the warm, or growing season, percentages of normal precipitation are of more vital interest and in this connection attention is called to figure 2 in regard to their distributions relative to the normal of 100, and especially to the marked deficiency in Nebraska (61), California (67), South Dakota (73), Illinois (75), and Missouri (76).

The actual values in inches of the monthly section averages of precipitation, the extremes of which have been mentioned already, are given in table 3, from which the annual march of monthly amounts may be readily noted, as is the march of percentages of normal in table 2.

One feature of the distribution of rainfall that is not to be omitted from this short summary is the heavy precipitation over more or less widespread areas in the southern tier of States from Eastern Texas to Florida in all months except January, March, May, and October, as shown in the total precipitation charts in current issues of this Review. The marked annual excesses in this region, and also in California, stand out clearly on the Chart of Annual Precipitation Departure.

TABLE 3.—*Monthly and Annual Precipitation (in inches), 1940*

Section	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Ala	4.34	6.89	5.25	3.57	3.45	6.43	8.46	2.93	1.47	1.40	3.49	6.30	53.98
Ariz	.76	1.86	.22	.84	.33	.90	.95	2.26	2.76	1.63	1.16	3.70	17.37
Ark	1.56	3.31	2.39	6.93	3.62	4.35	4.14	4.96	1.83	1.91	5.93	3.86	44.79
Calif	8.41	8.44	4.30	1.28	.63	.08	.01	.01	.40	1.76	1.42	9.16	35.90
Colo	1.42	1.27	1.27	1.56	1.74	.79	1.66	1.43	2.79	.83	1.01	1.11	16.88
Fla	2.58	4.56	3.53	2.77	1.90	6.89	8.31	7.18	6.72	.83	1.20	5.77	52.33
Ga	4.44	5.34	4.03	3.03	2.14	4.68	6.69	7.00	1.04	.89	3.73	4.14	47.24
Idaho	2.47	3.56	2.36	2.18	.55	.72	.75	.10	3.32	2.18	2.03	1.74	21.96
Ill	1.47	1.61	2.02	4.08	3.24	2.92	1.53	4.01	.64	2.14	2.89	2.05	28.60
Ind	1.67	2.59	1.89	5.58	4.14	3.11	1.49	2.74	1.17	2.23	3.59	2.37	32.57
Iowa	.83	1.18	1.72	3.22	2.07	3.56	4.56	6.44	.94	2.32	2.45	1.36	30.65
Kan	.82	.93	1.31	2.97	3.76	2.68	1.58	4.39	2.50	1.05	2.66	1.02	25.67
Ky	1.67	4.56	5.02	4.88	3.50	3.39	2.68	3.57	1.97	.74	3.70	3.16	38.84
La	2.96	7.15	3.41	9.44	1.89	9.33	7.51	10.83	3.74	1.28	8.21	8.92	74.67
Md.-Del	2.23	2.91	3.92	5.78	4.55	2.09	3.28	5.38	3.31	2.34	4.98	2.48	43.25
Mich	2.27	1.16	1.45	1.97	3.93	4.45	1.91	5.16	2.35	2.63	3.22	2.16	32.66
Minn	.26	.81	1.93	2.59	1.91	3.67	2.68	4.51	1.01	2.77	2.59	.75	25.48
Miss	3.09	6.27	4.55	6.96	2.59	6.09	10.38	3.84	2.40	1.24	5.64	7.53	60.58
Mo	1.35	1.59	2.44	4.41	2.44	4.36	1.58	5.78	.69	1.73	3.46	2.58	32.41
Mont	.66	1.43	1.01	2.19	1.19	2.02	1.65	.28	1.86	1.37	1.13	.40	15.25
Nebr	.72	.60	1.58	2.24	1.07	2.81	1.75	1.88	1.22	1.49	1.06	.93	17.35
Nev	2.31	1.62	.92	1.24	.23	.41	.01	.08	1.13	.86	.52	1.70	11.03
N. Eng	2.05	3.19	4.22	5.28	4.60	3.62	3.61	1.88	3.98	1.29	5.90	3.13	42.75
N. J	1.94	3.03	5.14	5.62	6.32	3.28	2.73	5.96	4.41	2.36	4.66	3.00	48.45
N. Mex	.59	1.19	.56	.66	1.85	1.10	1.55	2.45	1.52	.70	1.70	1.14	15.01
N. Y	1.70	3.12	4.36	3.87	3.78	4.21	3.36	2.68	3.37	2.17	3.78	3.89	40.29
N. C	3.07	3.50	3.12	3.46	3.81	3.56	4.26	10.57	1.48	1.28	4.19	3.00	45.30
N. Dak	.10	.61	.87	2.22	1.97	2.24	3.70	2.05	1.06	1.56	.59	.42	17.39
Ohio	1.46	3.17	2.96	5.53	4.51	4.79	1.93	4.18	1.54	1.63	3.45	3.00	38.15
Okla	.79	2.19	.46	5.03	3.87	3.49	3.47	3.36	2.83	1.71	4.75	1.83	33.78
Oreg	2.93	6.50	3.64	2.08	.97	.30	.61	.04	2.87	2.94	3.27	3.40	29.55
Pa	1.41	3.16	4.89	5.30	4.46	4.11	3.25	4.57	3.41	2.03	4.04	3.07	43.70
S. C	3.52	4.50	3.38	2.07	2.84	3.45	3.60	10.22	1.39	.93	4.13	2.76	42.79
S. Dak	.19	.62	1.75	2.70	.61	3.01	1.76	2.24	.75	1.02	.67	.39	15.71
Tenn	2.02	5.18	5.77	4.55	3.29	4.04	4.08	4.14	1.07	1.91	3.52	3.31	42.88
Tex	.83	2.38	1.11	3.06	3.36	5.48	1.97	2.85	1.40	2.52	6.22	3.86	35.04
Utah	2.24	2.19	1.24	1.46	.23	.44	.38	.56	2.72	1.39	1.25	1.68	15.78
Va	2.46	2.62	2.58	4.34	4.46	3.87	5.16	9.26	1.57	1.63	4.27	2.45	44.67
Wash	2.92	7.31	4.12	2.79	1.56	.40	1.18	.37	2.03	4.85	3.97	4.50	36.00
W. Va	1.44	3.84	3.70	5.13	4.93	5.97	4.43	4.83	2.88	1.80	3.27	2.31	44.53
Wis	.89	1.05	1.25	2.50	3.63	6.56	2.73	6.10	1.24	2.13	3.35	1.39	32.82
Wyo	1.19	.98	1.05	2.52	.87	1.38	1.20	.51	2.29	.97	.96	.56	14.48

METEOROLOGICAL AND CLIMATOLOGICAL DATA FOR FEBRUARY 1941

[Climate and Crop Weather Division, J. B. KINCER in charge]

AEROLOGICAL OBSERVATIONS

By EARL C. THOM

Mean surface temperatures for February were above normal over about two-thirds of the United States (chart I). Temperatures were below normal for the month from the southern Great Lakes southwestward to the Texas Panhandle, and were above normal over all other sections. A small area in northern Montana had a mean temperature 12° F. above normal for the month while the largest opposite departure, −8° F., occurred along the southern Atlantic coast.

At the 1,500 m. level the 5 a. m. resultant winds were from directions to the north of normal for the month at most stations in the eastern two-thirds of the country, while at this level resultant winds showed the opposite turning from normal at all stations to the westward. At 13 of the pilot-balloon stations, for which 5 a. m. normals are available, February resultants were not computed for the 3,000 m. level since less than 10 of the morning observations at these stations reached this level. At all stations west of the Great Divide, for which this comparison could be made, the directions of the resultant winds were to the south of normal at 3,000 meters while, with only two exceptions, the opposite turning from normal occurred at this level at all of the corresponding stations to the eastward.

It is interesting to note that a large area of above-normal precipitation was reported over the southwest, the west central, and over the west Gulf areas (chart V). This area was divided into two well-defined portions; one of these, the larger, lying west of the Great Divide, and the other including all of the States of Texas, Oklahoma, and parts of Kansas, Arkansas, and Lousiana. It appears likely that the directions of the resultant winds being considerably to the south of the corresponding normal directions over the areas west of the Great Divide at both the 1,500 m. and the 3,000 m. levels was responsible for more than normal amount of free-air moisture in these sections of the United States.

Nine stations of those for which 5 a. m. normals are available for the 5,000 m. level had 10 or more 5 p. m. observations which reached this higher level. At 3 of these stations, all in the northwest, the directions of the 5 p. m. resultant winds were considerably south of the corresponding 5 a. m. normals. At the other 6 widely scattered stations the evening resultants for the month at 5,000 meters were from directions to the north of the morning normals for this level.

The departure of the 5 a. m. resultant velocities from normal for the month at the 1,500 m. level were about equally distributed over the United States. The resultant velocities at this level were above normal along the Pacific coast, below normal along the northern half of the Atlantic coast, while the positive and negative departures from normal velocity were distributed without any well-defined areas over most of the country. At 3,000 meters resultant velocities were below normal over all of the Rocky Mountain Plateau region. At only 12 widely scattered stations outside of this region could this comparison be made for the month at this level. At 8 of these stations resultant velocities were above normal while they were below normal over the other four. At 2 of the 9 stations at which the 5 p. m. resultants at 5,000 meters could be compared with the 5 a. m. normals for the month, the afternoon resultant velocities were below the morning normals while they were above these normals at the other 7 stations.

The directions of the 5 p. m. resultant winds were to the south of the direction of the corresponding 5 a. m. resultant winds at 1,500 meters over the area west of the Great Divide, and a portion of the southeastern States, while no well-defined areas of definite turning of the resultant winds during the day were noted elsewhere at this level. There were 12 of the stations (shown in table 2) at which 5 a. m. resultants were not computed this month for the 3,000 m. level. At 2 of the stations on the Pacific coast and at 5 stations near the Gulf of Mexico the directions of the 5 p. m. resultant winds were to the north of the corresponding morning winds at this level while the opposite turning in resultant winds during the day was indicated at most of the other stations at which these directions could be compared.

The 5 p. m. resultant velocities for the month were lower than the 5 a. m. resultant velocities at the 1,500 m. level over the northeast, the north central and over most of the south central States and were higher than the morning velocities for this level at most stations in the other sections of the United States. At 3,000 meters only 7 stations, all located in the Rocky Mountain Plateau region, had 5 p. m. resultant velocities lower than the corresponding 5 a. m. velocities. The afternoon velocities were higher than the morning velocities at this level over all other stations, being especially pronounced over the southeastern States.

The upper-air data discussed above are based on 5 a. m. (e. s. t.) observations (charts VIII and IX) as well as on observations made at 5 p. m. (table 2, and charts X and XI).

At radiosonde and airplane stations in the United States proper the highest mean pressure was recorded at Brownsville at the 1,000 m., 2,000 m., 4,000 m., and 5,000 m. levels and again at the 14,000 m., 15,000 m., and 16,000 m., levels. The same maximum mean pressure for each level was recorded at both Brownsville and Miami at the 1,500, 2,500, and 6,000 m. levels while the maximum mean pressure for the month was observed over Miami at all standard levels from 7,000 to 13,000 meters, inclusive. The lowest mean pressure for the month was observed over Portland, Maine, at standard levels, from 1,000 to 4,000 meters inclusive, and over Sault Ste. Marie at standard levels from 5,000 to 16,000 meters.

At each of the standard levels below 13,000 meters the mean pressures over Nome, Alaska, were lower than the minimum pressures reported for the corresponding levels over stations in the United States proper. Mean pressure for the month at most standard levels over Fairbanks and over other Alaskan stations south of 65° N. latitude, however, while lower than the mean pressure over most stations in the United States were not as low as the corresponding minima. Mean pressures at all standard levels below 17,000 meters were higher over San Juan than the corresponding maxima for stations in the United States.

With but few exceptions mean pressures were lower in February than in the previous month over the United States at all standard levels below 12,000 meters. At levels above 12,000 meters mean pressures were either the same as, or slightly higher than, in January over most of the country, only six stations reporting small negative pressure changes at one or more of these higher levels. Over Fairbanks and over all radiosonde stations in Alaska south of 64° N. latitude, mean pressures were higher than in January at all reported standard levels above 1,000 meters (m. s. l.), while at Nome mean pressures were lower than last month at standard levels up to 9,000 meters and were slightly higher above that level.

The largest difference between the maximum and minimum mean monthly pressure at any level for stations in the United States was 34 mb. at 8,000 meters. Steep pressure gradients appear on the mean pressure charts, extending from north to south across the eastern third of the country particularly at the standard levels from 5,000 to 9,000 meters. At the 7,000 and 8,000 m. levels, for example, a change of 1 mb. is noted for each 44 miles of horizontal distance between Sault Ste. Marie and Pensacola.

The February mean temperatures were generally higher than those in January for stations in the western third of the United States at all standard levels below 8,000 meters and were generally lower than last month at these levels over most stations to the eastward. With but few exceptions mean temperatures were higher than last month over all stations in the United States at levels above 8,000 meters. Mean temperatures for the month were higher than those for January over all radiosonde stations in Alaska (Barrow data not available) north of 60° N. latitude at most levels, the only exception being small opposite temperature changes over Nome at levels from 2,000 to 5,000 meters. At Ketchikan and at Juneau mean temperatures were higher than in January at standard levels from 1,500 to 10,000 meters, inclusive, and were lower at all higher levels at which mean temperatures could be compared.

Mean temperatures at nearly all standard levels below 2,500 meters were higher than those for February 1940 over stations west of the Great Divide and over stations in the south central and gulf coast regions while mean temperatures at these levels were generally lower than last year over all other stations reporting data for this month in both 1941 and 1940. Almost without exception, mean temperatures were higher than in February of last year at standard levels from 2,500 to 6,000 m., inclusive, over all stations west of a line drawn across the United States through Williston, N. Dak., and Shreveport, La., and were lower than last year over stations east of this line. At most stations in the United States temperatures were higher than in February last year at all standard levels

above 8,000 meters. Mean temperatures were higher than last year at all levels over Fairbanks, Alaska, and at levels below 9,000 meters over Juneau but they were slightly lower than in February 1940 at all the higher levels over the latter station.

The mean surface temperature for February, as recorded by radiosonde observations, was 0° C. or lower over all of the northern half of the United States except at Medford, Seattle, and Spokane. At Ely and at Denver, where the mean surface temperatures were below freezing, temperature inversions observed during the month resulted in two levels above the surface at which the mean temperature was 0° C., the upper of these two levels being about 2,100 meters (m. s. l.) at Denver and 2,000 meters at Ely. The level at which the mean temperature was 0° C. over the rest of the United States varied from 500 meters (m. s. l.) over Nashville to 3,800 meters over both Miami and Brownsville. A monthly mean temperature of freezing occurred at lower levels than in January over Norfolk, Nashville, Charleston, and Pensacola and at higher levels than last month at all other stations.

The lowest temperature recorded in the free air over the United States was −81° C. (−115.2° F.) recorded on February 14, at a height of 16,400 meters (about 10 miles) above sea level over Miami, Fla. A lower temperature −91.6° C. (−132.9°) was, however, recorded at 17,000 meters over Swan Island on February 16.

Table 3 shows the maximum free-air wind velocities and their directions for various sections of the United States during February as determined by pilot-balloon observations. The highest wind velocity reported for the month was 91.6 meters per second (204.9 m. p. h.) observed over Albuquerque, N. Mex., on February 9. This high wind was blowing from the NNW. at an altitude of 9,820 meters (about 6 miles) above sea level.

The highest wind velocity observed in the free-air layer below 2,500 meters during February in the last five years was 49.0 m. p. s. over Sandberg, Calif., in 1939. In the free-air layer from 2,500 to 5,000 meters the highest February wind velocity during this period was 80.0 m. p. s. over Winslow, Ariz., in 1941, while at levels above 5,000 meters the corresponding extreme occurred this year. (See previous paragraph.)

Tropopause data formerly shown in table 4 and on chart XIII are discontinued with this issue of the MONTHLY WEATHER REVIEW.

TABLE 1.—*Mean free-air barometric pressure in millibars, temperature in degrees centigrade, and relative humidities in percent obtained by airplanes and radiosondes during February 1941*

Stations with elevations in meters above sea level

Altitude (meters) m. s. l.	Anchorage, Alaska (41 m.)				Atlantic Station No. 2 (3 m.)[4]				Barrow, Alaska (6 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	28	1,001	−1.6	72	25	1,012	15.1	77	....	....	....	....
500	28	945	−1.2	70	25	954	10.9	82	....	....	....	....
1,000	28	887	−2.4	67	25	898	7.4	82	....	....	....	....
1,500	28	832	−5.2	66	25	845	5.0	78	....	....	....	....
2,000	28	780	−8.5	66	25	794	2.8	73	....	....	....	....
2,500	28	732	−11.5	66	24	747	1.1	62	....	....	....	....
3,000	28	686	−14.7	66	24	701	−1.3	56	....	....	....	....
4,000	28	600	−21.0	65	24	618	−7.1	52	....	....	....	....
5,000	28	523	−27.8	64	23	543	−13.9	49	....	....	....	....
6,000	27	454	−34.4	62	20	475	−20.7	52	....	....	....	....
7,000	27	393	−41.1	....	18	414	−27.6	53	....	....	....	....
8,000	27	338	−47.3	....	17	359	−35.2	....	....	....	....	....
9,000	26	290	−51.9	....	14	310	−42.6	....	....	....	....	....
10,000	25	249	−53.6	....	11	267	−48.2	....	....	....	....	....
11,000	24	214	−51.0	....	10	229	−51.6	....	....	....	....	....
12,000	23	183	−47.9	....	8	196	−52.3	....	....	....	....	....
13,000	23	158	−47.3	....	7	168	−51.4	....	....	....	....	....
14,000	23	135	−47.3	....	7	145	−52.4	....	....	....	....	....
15,000	23	117	−47.6	....	7	125	−54.7	....	....	....	....	....
16,000	17	100	−48.1	....	6	106	−56.9	....	....	....	....	....
17,000	14	86	−48.5	....	6	91	−56.5	....	....	....	....	....
18,000	9	74	−49.0	....	....	....	....	....	....	....	....	....
19,000	....	....	....	....	....	....	....	....	....	....	....	....
20,000	....	....	....	....	....	....	....	....	....	....	....	....
21,000	....	....	....	....	....	....	....	....	....	....	....	....

Altitude (meters) m. s. l.	Bethel, Alaska (7 m.)				Bismarck, N. Dak. (505 m.)				Brownsville, Tex. (6 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	27	1,000	−7.5	79	27	960	−11.2	84	28	1,017	+13.8	92
500	27	939	−3.6	72	....	....	....	....	28	959	+13.1	86
1,000	27	881	−4.7	70	27	901	−9.4	80	28	904	+11.8	74
1,500	27	827	−7.2	68	27	845	−7.8	71	28	851	+10.3	66
2,000	27	775	−10.4	68	27	791	−8.1	66	28	801	+8.9	59
2,500	27	726	−13.7	67	27	742	−9.5	64	28	754	+7.2	50
3,000	27	679	−17.1	64	27	695	−11.6	62	28	710	+5.0	47
4,000	27	593	−23.3	59	27	610	−17.1	63	27	627	−0.9	44
5,000	27	517	−30.1	56	27	533	−23.3	64	26	553	−7.8	48
6,000	26	448	−36.8	54	27	464	−30.2	63	26	485	−14.7	49
7,000	26	387	−43.4	....	27	402	−37.6	62	26	424	−21.2	46
8,000	26	333	−49.1	....	26	347	−44.5	....	26	370	−28.2	44
9,000	25	286	−51.0	....	24	298	−50.5	....	26	321	−35.1	42
10,000	25	245	−50.0	....	24	256	−55.3	....	26	278	−41.9	....
11,000	25	211	−46.9	....	24	219	−54.9	....	26	239	−47.7	....
12,000	24	181	−45.7	....	24	187	−52.0	....	26	205	−52.8	....
13,000	22	156	−43.1	....	24	160	−51.4	....	26	175	−57.3	....
14,000	19	134	−43.6	....	23	137	−51.9	....	26	150	−61.3	....
15,000	15	116	−43.4	....	18	118	−52.8	....	26	127	−66.1	....
16,000	11	99	−44.3	....	16	101	−53.7	....	25	108	−70.1	....
17,000	8	85	−44.7	....	11	86	−54.4	....	22	91	−71.5	....
18,000	5	72	−44.8	....	....	....	....	....	16	77	−70.2	....
19,000	....	....	....	....	....	....	....	....	10	65	−66.5	....
20,000	....	....	....	....	....	....	....	....	6	55	−63.2	....
21,000	....	....	....	....	....	....	....	....	5	47	−62.0	....

See footnotes at end of table.

TABLE 1.—*Mean free-air barometric pressure in millibars, temperature in degrees centigrade, and relative humidities in percent obtained by airplanes and radiosondes during February 1941*—Continued

Stations with elevations in meters above sea level

Altitude (meters) m. s. l.	Buffalo, N. Y. (221 m.)				Charleston, S. C. (14 m.)				Coco Solo, C. Z.[1 2] (1 m.)				Denver, Col. (1,616 m.)				El Paso, Tex. (1,193 m.)				Ely, Nev. (1,908 m.)				Fairbanks, Alaska (153 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	28	987	−5.8	85	28	1,015	3.5	79	21	1,013	26.5	85	28	837	−1.2	78	28	882	9.4	62	28	807	−0.3	86	28	991	−8.0	59
500	28	952	−5.9	88	28	956	6.0	65	21	958	23.5	91													28	947	−5.0	58
1,000	28	893	−8.2	88	28	899	4.2	60	21	904	20.4	85													28	890	−6.5	56
1,500	28	837	−10.0	84	28	845	2.2	57	21	853	18.1	75					28	850	9.6	62					28	834	−7.4	52
2,000	27	784	−11.5	79	28	794	0.5	53	21	804	15.7	71	28	797	+0.2	70	28	800	6.5	60	28	798	+0.1	84	28	782	−9.9	49
2,500	27	735	−13.2	75	28	746	−0.7	49	20	758	13.4	66	28	749	−1.5	62	28	752	2.9	62	28	750	−1.4	76	28	732	−12.9	48
3,000	27	688	−14.9	71	28	701	−2.7	46	19	714	11.3	45	28	703	−4.3	59	28	707	−0.1	63	28	704	−4.4	73	28	686	−16.1	49
4,000	27	602	−19.7	67	28	617	−7.9	44	16	633	5.0	36	27	618	−10.9	55	28	623	−6.1	59	28	619	−10.5	66	28	600	−22.6	50
5,000	27	526	−25.8	65	26	542	−13.9	44					27	542	−18.0	53	28	548	−12.3	52	28	543	−17.3	59	28	522	−29.3	49
6,000	27	457	−32.3	62	26	474	−20.7	42					25	474	−25.2	50	28	480	−19.1	50	28	474	−24.2	57	28	453	−35.9	49
7,000	27	395	−39.2	62	26	413	−27.6	40					25	412	−32.7	48	28	419	−26.6	49	28	413	−31.3	53	27	392	−42.6	
8,000	26	341	−45.4		25	359	−34.9	40					24	356	−40.2		27	363	−33.9	48	28	358	−39.3	51	26	337	−49.3	
9,000	25	293	−50.5		25	310	−42.1						24	307	−47.1		25	314	−40.7		27	308	−46.7		25	289	−53.7	
10,000	24	251	−53.0		24	267	−47.9						23	264	−53.5		25	271	−47.0		26	265	−53.6		25	248	−54.0	
11,000	24	216	−50.3		23	230	−51.2						22	226	−56.6		24	233	−51.2		24	227	−55.1		23	212	−51.2	
12,000	24	185	−49.3		22	197	−54.3						21	192	−54.9		24	199	−53.9		21	194	−53.4		23	182	−48.3	
13,000	23	158	−50.2		20	168	−56.3						20	164	−55.5		21	170	−56.9		21	166	−53.6		21	156	−47.2	
14,000	23	136	−51.6		19	143	−59.0						19	140	−57.3		19	145	−60.7		21	142	−54.9		20	134	−47.3	
15,000	19	116	−53.1		16	122	−61.2						19	120	−59.3		17	124	−64.4		21	122	−57.7		20	115	−48.3	
16,000	14	100	−54.3		12	104	−62.6						18	102	−60.9		15	105	−66.8		20	104	−59.8		20	98	−48.8	
17,000	11	85	−55.7		11	88	−63.9						18	87	−61.5		15	89	−67.4		18	88	−61.0		14	85	−49.1	
18,000					8	75	−64.1						9	74	−62.0		10	76	−66.6		13	75	−61.8		6	72	−49.5	
19,000					6	64	−62.5														5	64	−60.8					

Stations with elevations in meters above sea level

Altitude (meters) m. s. l.	Great Falls, Mont. (1,117 m.)				Joliet, Ill. (178 m.)				Juneau, Alaska (49 m.)				Ketchikan, Alaska (26 m.)				Lakehurst, N. J.[1] (39 m.)				Medford, Oreg. (401 m.)				Miami, Fla. (4 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	28	887	−2.8	64	28	996	−5.5	89	27	1,007	1.5	66	26	1,010	2.5	72	26	1,009	−4.3	72	27	965	7.3	77	27	1,015	14.8	88
500					28	955	−6.3	89	27	952	−1.0	67	26	952	0.9	67	26	951	−5.3	67	27	953	7.8	75	27	958	14.8	80
1,000					28	896	−7.8	84	27	894	−3.8	66	26	895	−2.3	65	26	893	−6.9	64	27	897	6.7	68	27	903	12.3	77
1,500	28	846	−2.1	64	28	840	−8.5	77	27	838	−6.4	68	26	840	−4.1	62	26	837	−8.1	61	27	843	3.4	69	27	851	9.8	69
2,000	28	794	−3.3	62	28	788	−9.7	70	27	786	−8.2	68	26	788	−6.3	57	26	784	−9.3	56	27	793	0.4	69	27	800	8.3	58
2,500	28	745	−5.0	62	28	739	−10.9	65	27	737	−10.3	63	26	738	−9.0	55	26	735	−11.3	54	27	745	−2.8	68	27	754	6.7	48
3,000	28	699	−8.1	62	28	691	−12.7	61	24	690	−12.9	60	26	692	−11.8	53	26	688	−13.7	51	27	699	−5.5	61	27	709	4.2	44
4,000	28	614	−14.0	56	28	606	−17.8	58	24	604	−18.8	55	26	606	−18.3	51	26	602	−18.8	52	27	614	−11.6	57	27	626	−1.0	42
5,000	28	537	−20.5	51	27	530	−24.0	57	20	528	−25.4	51	23	530	−24.6	50	26	526	−25.2	52	26	539	−18.3	55	26	552	−6.8	42
6,000	28	469	−27.4	50	27	461	−30.4	55	16	459	−32.2	50	23	461	−31.2	50	26	458	−31.4	51	26	470	−25.5	53	26	485	−13.4	42
7,000	28	407	−34.9	50	26	400	−37.3	53	14	396	−39.1		23	399	−38.6	50	26	396	−37.0	53	26	409	−32.9	51	26	425	−20.0	44
8,000	28	352	−42.6		26	345	−43.9		14	342	−45.9		22	344	−46.0		24	342	−42.8		26	354	−40.2		26	371	−26.9	42
9,000	28	303	−50.0		26	296	−50.0		13	293	−52.0		21	295	−52.2		23	294	−47.7		26	304	−47.6		26	322	−34.2	39
10,000	27	259	−56.0		25	254	−54.0		12	250	−54.7		21	252	−55.1		21	253	−49.7		26	261	−53.8		26	279	−41.4	
11,000	27	222	−58.3		24	217	−54.5		12	214	−53.7		20	216	−54.8		21	218	−49.9		26	224	−56.4		24	240	−48.2	
12,000	26	189	−55.5		24	186	−53.3		11	183	−51.2		18	184	−52.4		18	187	−50.6		26	191	−54.8		23	206	−54.0	
13,000	25	162	−53.5		24	159	−53.0		10	157	−51.1		18	158	−51.1		15	161	−52.5		25	164	−54.5		22	176	−59.7	
14,000	25	139	−53.6		24	136	−53.8		10	134	−50.5		17	135	−51.1		15	139	−54.5		25	140	−55.3		21	149	−64.8	
15,000	24	119	−54.8		21	116	−55.1		8	114	−50.8		16	116	−51.6		13	119	−56.3		23	120	−56.1		20	126	−70.0	
16,000	22	102	−55.8		19	99	−56.8		6	98	−51.4		14	99	−52.1		8	102	−58.3		19	102	−58.0		19	107	−74.5	
17,000	19	87	−56.2		18	84	−57.8						9	85	−53.0		5	87	−60.3		15	87	−59.2		17	90	−76.0	
18,000	10	74	−56.4		15	72	−58.2														11	74	−59.5		14	76	−74.6	
19,000	7	63	−57.0		10	61	−58.3														7	62	−60.0		10	64	−70.0	
20,000																									5	54	−66.7	

See footnotes at end of table.

TABLE 1.—*Mean free-air barometric pressure in millibars, temperature in degrees centigrade, and relative humidities in percent obtained by airplanes and radiosondes during February 1941*—Continued

Stations with elevations in meters above sea level

Altitude (meters) m. s. l.	Nashville, Tenn. (180 m.)				Nome, Alaska (14 m.)				Norfolk, Va.[1 3] (10 m.)				Oakland, Calif. (2 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	28	997	1.0	70	28	1,005	−9.4	75	17	1,018	0.1	61	28	1,013	11.0	88
500	28	958	0.0	72	28	944	−9.4	77	17	957	−1.1	50	28	955	10.2	81
1,000	28	900	−2.3	73	28	885	−10.4	74	17	899	−2.9	42	28	899	7.7	76
1,500	28	845	−3.4	71	28	829	−12.4	69	17	843	−4.4	39	28	846	5.1	71
2,000	28	793	−4.5	70	28	776	−15.0	64	17	791	−6.3	33	28	795	2.2	67
2,500	28	744	−5.9	66	28	726	−17.9	62	17	742	−7.2	28	28	747	−0.4	62
3,000	28	698	−8.0	65	28	678	−20.7	60	17	696	−8.8	24	28	702	−2.9	59
4,000	27	613	−12.6	61	28	592	−26.7	56	17	611	−12.9	23	27	618	−9.1	55
5,000	27	538	−18.7	56	28	514	−33.3	53	10	535	−19.0	24	27	542	−16.0	54
6,000	26	470	−25.3	51	27	446	−40.0	50					26	474	−23.3	52
7,000	26	409	−32.1	49	27	384	−45.9						26	412	−30.6	50
8,000	26	354	−39.6	48	27	330	−50.5						26	358	−38.4	50
9,000	24	305	−46.7		27	283	−52.4						25	308	−45.5	
10,000	24	262	−52.4		27	242	−50.9						25	265	−50.9	
11,000	24	224	−55.1		27	208	−48.6						24	227	−52.5	
12,000	22	192	−55.0		26	179	−47.1						24	194	−51.1	
13,000	22	164	−56.4		25	153	−46.8						24	166	−52.8	
14,000	20	140	−58.2		24	132	−46.9						24	143	−55.1	
15,000	16	119	−60.2		24	114	−47.5						24	122	−57.6	
16,000	16	101	−61.8		22	97	−48.3						23	104	−60.2	
17,000	12	86	−62.8		12	84	−49.0						18	89	−60.2	
18,000	7	73	−63.2		5	72	−49.3						14	75	−60.9	
19,000													6	64	−60.9	

Altitude (meters) m. s. l.	Oklahoma City, Okla. (391 m.)				Omaha, Nebr. (301 m.)				Pearl Harbor, T. H. (6 m.[1 2])			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	23	972	3.3	76	28	984	−3.9	81	28	1,016	18.9	82
500	23	960	4.0	75	28	960	−4.6	79	28	960	18.0	74
1,000	23	902	3.4	65	28	901	−5.1	69	28	906	15.0	77
1,500	23	848	2.8	59	28	846	−4.1	61	28	854	12.5	73
2,000	23	797	1.2	58	28	793	−5.0	56	28	804	10.9	59
2,500	23	749	0.0	54	28	744	−6.7	55	28	757	10.7	32
3,000	23	703	−2.5	53	28	698	−8.9	55	28	714	9.4	21
4,000	23	619	−8.8	51	28	613	−14.4	52	28	632	4.7	13
5,000	23	544	−15.2	49	27	537	−20.4	51				
6,000	22	475	−22.2	47	27	468	−27.4	50				
7,000	20	414	−29.4	44	26	406	−35.1	49				
8,000	20	359	−37.2	41	26	351	−42.4					
9,000	19	310	−44.1		25	302	−49.7					
10,000	18	267	−48.8		23	259	−54.7					
11,000	17	229	−52.5		23	222	−55.5					
12,000	17	196	−53.2		23	189	−54.0					
13,000	17	167	−55.7		23	162	−53.6					
14,000	16	143	−58.1		22	138	−54.9					
15,000	12	122	−61.0		21	118	−56.1					
16,000	11	103	−63.1		21	101	−57.3					
17,000	8	88	−64.0		18	86	−58.5					
18,000					7	73	−58.4					
19,000												

Stations with elevations in meters above sea level

Altitude (meters) m. s. l.	Pensacola, Fla.[1] (24 m.)				Phoenix, Ariz. (339 m.)				Portland, Maine (9 m.)				St. Louis, Mo. (171 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	28	1,016	10.3	70	28	975	12.2	82	28	1,006	−6.1	76	28	999	−1.0	69
500	28	960	8.2	64	28	957	14.3	69	28	946	−6.2	76	28	959	−2.2	70
1,000	28	903	6.4	59	28	902	12.1	61	28	888	−7.6	73	28	900	−4.4	70
1,500	28	849	5.3	52	28	849	8.7	62	28	832	−8.6	69	28	844	−5.0	70
2,000	28	799	3.6	46	28	799	5.3	63	28	780	−10.7	67	28	792	−5.8	66
2,500	28	750	1.3	42	28	751	2.2	61	28	731	−12.8	66	28	743	−7.5	60
3,000	28	705	−0.8	40	28	706	−0.5	54	28	684	−14.7	64	28	696	−9.8	58
4,000	28	621	−5.7	43	27	622	−6.2	46	27	598	−19.7	61	27	611	−14.8	55
5,000	28	547	−12.0	44	27	547	−12.8	43	26	523	−26.0	59	26	535	−20.7	53
6,000	28	479	−18.9	46	26	479	−19.6	42	26	455	−32.5	58	26	466	−27.2	50
7,000	28	418	−26.0	51	26	418	−27.0	41	25	394	−39.5	58	26	405	−34.0	47
8,000	23	363	−33.0	52	26	363	−34.3	40	24	339	−45.4		24	350	−41.0	
9,000	20	314	−39.3	53	21	314	−41.6		24	291	−49.8		24	302	−47.6	
10,000	16	271	−45.8		20	270	−46.8		23	250	−51.9		22	258	−53.3	
11,000	10	233	−52.3		17	232	−50.1		23	215	−50.8		20	222	−54.7	
12,000	5	199	−58.6		14	199	−51.3		20	184	−50.2		18	189	−53.1	
13,000	5	170	−63.8		14	170	−53.5		19	158	−50.3		15	162	−53.5	
14,000					14	146	−56.2		18	135	−51.5		15	138	−54.4	
15,000					14	124	−59.3		17	115	−52.6		9	117	−56.4	
16,000					12	106	−62.2		14	99	−53.7		7	100	−58.5	
17,000					9	90	−62.8		11	84	−55.5		5	85	−58.8	
18,000					6	76	−63.0		5	72	−57.0					

Altitude (meters) m. s. l.	St. Paul, Minn. (214 m.)				St. Thomas, V. I.[1 2] (8 m.)				San Diego, Calif.[1] (19 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	28	992	−9.2	81	28	1,017	25.2	80	25	1,012	14.3	87
500	28	958	−10.3	81	28	961	20.5	96	25	956	12.7	76
1,000	28	898	−10.3	82	28	907	17.2	95	25	900	10.0	69
1,500	28	841	−9.1	76	28	856	14.6	86	25	847	7.1	64
2,000	28	788	−9.9	71	28	806	13.0	68	25	798	4.8	53
2,500	28	739	−12.1	66	28	760	11.4	53	25	750	2.5	47
3,000	28	692	−14.0	64	28	715	9.2	42	25	705	0.3	38
4,000	28	606	−18.5	61	28	634	5.1	27	24	621	−5.7	33
5,000	27	529	−24.7	58					24	545	−12.2	38
6,000	27	461	−30.6	56					24	478	−19.4	45
7,000	27	399	−37.8	54					23	417	−26.5	48
8,000	26	344	−44.5						21	362	−33.2	
9,000	25	296	−50.1						19	313	−39.9	
10,000	24	253	−53.2						19	270	−45.7	
11,000	22	218	−53.0						17	232	−49.5	
12,000	21	187	−51.4						15	199	−52.4	
13,000	21	160	−50.7						13	171	−56.0	
14,000	20	138	−51.7						13	146	−59.0	
15,000	20	118	−52.8						10	124	−61.4	
16,000	20	101	−53.9						8	106	−64.4	
17,000	13	87	−54.3						6	89	−67.0	
18,000	7	75	−55.1									

See footnotes at end of table.

TABLE 1.—*Mean free-air barometric pressure in millibars, temperatuue in degrees centigrade, and relative humidities in percent obtained by airplanes radiosondes during February 1941*—Continued

Altitude (meters) m. s. l.	San Juan, P. R. (15 m.)				Sault Ste. Marie, Mich. (221 m.)				Seattle, Wash.[1] (27 m.)				Spokane, Wash. (598 m.)				Swan Island, W. I. (10 m.)				Washington, D. C.[1] (7 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	27	1,014	23.0	87	28	987	−8.4	87	28	1,010	7.6	79	27	945	1.1	90	28	1,013	24.5	78	21	1,015	−1.5	69
500	27	959	21.1	84	28	952	−9.3	89	28	954	7.5	63					28	957	20.9	86	21	954	−3.0	65
1,000	27	905	17.9	82	28	892	−10.6	89	28	898	4.5	61	27	899	1.7	83	28	904	18.0	83	21	896	−5.2	64
1,500	27	854	15.6	74	28	836	−11.5	85	28	844	1.4	61	27	845	0.1	75	28	852	15.2	77	21	840	−7.2	62
2,000	27	805	14.2	58	28	783	−13.4	84	28	793	−1.3	59	27	793	−2.5	69	28	803	13.0	71	21	788	−8.8	59
2,500	27	758	11.8	45	28	733	−15.1	80	28	744	−4.5	59	27	745	−5.1	65	28	757	11.6	59	21	738	−10.5	55
3,000	27	714	9.2	38	28	686	−17.2	75	28	698	−7.5	56	27	699	−7.6	62	28	712	9.8	49	21	692	−12.1	51
4,000	27	632	4.9	28	28	599	−22.2	70	27	613	−13.9	51	27	614	−13.8	59	28	631	4.8	35	20	606	−16.6	49
5,000	27	559	−0.6	25	28	522	−28.3	67	27	536	−20.7	49	27	537	−20.7	57	27	558	−0.6	30	17	529	−22.1	47
6,000	27	492	−7.1	23	27	454	−35.4	67	27	467	−28.1	50	27	468	−27.9	54	27	491	−6.8	27	17	461	−28.0	47
7,000	25	432	−13.6	22	27	392	−42.5		27	406	−35.5	54	27	406	−35.5	53	27	432	−13.5	25	9	399	−34.2	50
8,000	25	378	−20.6	22	27	337	−48.6		27	351	−43.0		27	351	−42.9		27	378	−20.7	24	6	347	−40.2	
9,000	25	329	−28.1	22	25	289	−53.1		27	302	−49.5		27	302	−49.6		27	329	−28.0	23	6	299	−46.6	
10,000	24	286	−35.9	22	25	247	−53.8		26	259	−55.2		27	259	−55.6		27	286	−35.0	23				
11,000	19	247	−43.6		25	212	−51.6		25	221	−57.8		27	221	−57.9		27	247	−42.9					
12,000	19	213	−51.0		25	181	−50.6		22	189	−56.1		24	189	−55.6		27	212	−50.9					
13,000	18	182	−58.4		22	155	−51.0		21	162	−53.6		24	161	−53.8		26	182	−58.9					
14,000	18	154	−65.5		19	134	−51.9		21	138	−53.2		22	138	−53.9		23	154	−67.2					
15,000	13	130	−72.7		19	114	−52.9		19	118	−54.0		22	118	−54.3		22	130	−75.5					
16,000	11	110	−78.9		13	98	−53.7		14	100	−55.0		21	101	−55.9		22	109	−83.3					
17,000	11	92	−82.7		7	84	−54.4		11	85	−55.8		18	87	−56.1		20	91	−86.2					
18,000	8	77	−79.8						5	72	−56.3		11	74	−56.2		16	76	−80.3					
19,000	6	65	−73.9														7	64	−74.0					

LATE REPORTS, TABLE 1, FOR NOVEMBER 1940

Altitude (meters) m. s. l.	Swan Island, W. I. (10 m.)				St. Thomas, V. I.[1 2] (8 m.)				Altitude (meters) m. s. l.	Swan Island, W. I. (10 m.)				St. Thomas, V. I.[1 2] (8 m.)			
	Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity		Number of observations	Pressure	Temperature	Relative humidity	Number of observations	Pressure	Temperature	Relative humidity
Surface	28	1,012	25.6	83	15	1,012	26.4	83	11,000	24	249	−42.8					
500	28	958	23.1	83	15	956	20.3	93	12,000	23	214	−50.9					
1,000	28	904	20.0	84	15	902	16.9	90	13,000	23	183	−58.9					
1,500	28	853	16.9	78	15	851	14.0	88	14,000	23	156	−66.1					
2,000	28	804	14.4	73	15	802	11.3	87	15,000	23	132	−72.2					
2,500	28	758	12.1	68	15	755	9.2	78	16,000	21	111	−75.8					
3,000	28	714	9.7	60	15	711	7.0	68	17,000	20	93	−78.3					
4,000	28	633	5.4	53	14	628	0.8	55	18,000	17	78	−77.8					
5,000	26	559	−0.1	44					19,000	14	66	−73.6					
6,000	26	493	−6.1	38					20,000	14	55	−69.6					
7,000	26	433	−12.3	35					21,000	13	47	−66.6					
8,000	26	379	−19.2	33					22,000	9	40	−63.3					
9,000	25	331	−26.5	32					23,000	6	33	−60.7					
10,000	24	288	−34.5	30													

[1] U. S. Navy.

[2] Airplane observations.

[3] Observations made on Coast Guard vessels in or near the 5° square; lat. 35.00′ N. to 40.00′ N.; long. 55.00′ W. to 60.00′ W.

[4] Observations made on Coast Guard vessels in or near the 5° square; lat. 35.00′ N. to 40.00′ N.; long. 45.00′ W. to 50.00′ W.

NOTE.—All observations taken at 12:30 a. m. 75th meridian time, except at Washington, D. C., and Lakehurst, N J., where they are taken near 5 a. m. E. S. T., at Norfolk, Va., where they are taken at about 6 a. m., and at Pearl Harbor, T. H., after sunrise.

None of the means included in this table are based on less than 15 surface or 5 standard level observations.

Number of observations refers to pressure only as temperature and humidity data are missing for some observations at certain levels, also, the humidity data are not used in daily observations when the temperature is below −40° C.

TABLE 2.—*Free-air resultant winds based on pilot-balloon observations made near 5 p. m. (75th meridian time) during February 1941. Directions given in degrees from North (N=360°, E=90°, S=180°, W=270°)—velocities in meters per second*

Altitude (meters) m. s. l.	Abilene, Tex. (537 m.)			Albuquerque, N. Mex. (1,630 m.)			Atlanta, Ga. (299 m.)			Billings, Mont. (1,095 m.)			Bismarck, N. Dak. (512 m.)			Boise, Idaho (870 m.)			Brownsville, Tex. (7 m.)			Buffalo, N. Y. (220 m.)			Burlington, Vt. (132 m.)			Charleston, S. C. (18 m.)			Chicago, Ill. (192 m.)			Cincinnati, Ohio (157 m.)			Denver, Colo. (1,627 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	23	265	1.4	28	294	1.5	27	318	4.5	28	273	1.3	28	307	1.2	24	108	1.4	23	46	1.5	26	270	4.6	27	318	1.1	27	289	2.4	25	289	3.7	28	293	2.7	27	53	1.9
500							27	310	5.0										23	42	1.4	26	257	6.2	27	262	2.1	27	287	4.3	25	289	4.0	28	276	4.7			
1,000	22	270	2.1				26	306	5.6				28	297	3.4	24	118	1.9	18	314	2.6	16	266	6.9	26	272	5.0	26	285	6.8	20	308	5.1	25	266	5.3			
1,500	16	246	2.4				25	302	8.5	28	256	2.2	27	299	5.5	24	149	3.5	15	287	4.6	14	293	5.6	21	283	7.6	24	281	9.6	15	291	5.5	22	276	6.9			
2,000	16	281	4.8	28	268	2.4	22	308	10.2	28	275	3.9	25	309	8.1	24	159	4.0	13	275	5.5	14	300	7.5	15	302	8.4	23	274	12.9	13	295	6.9	15	284	9.6	27	58	1.9
2,500	16	296	6.3	28	272	3.0	20	306	12.6	26	283	5.7	21	311	10.2	21	195	5.5	13	288	6.9	11	303	7.6	12	313	12.9	19	271	14.8	12	288	9.4	13	287	14.3	25	297	1.2
3,000	16	297	8.8	28	275	5.1	18	295	14.2	22	284	8.3	20	307	10.7	20	211	5.4	11	307	9.5	11	297	8.5				17	269	15.4	12	292	10.5	12	289	15.0	24	290	5.8
4,000	14	305	11.9	22	283	9.2	17	286	19.4	20	305	7.1	19	313	15.2	15	214	6.7	10	299	12.3										11	293	15.4				24	303	9.9
5,000	12	305	14.8	19	277	13.4	14	292	19.3	19	293	12.8	16	313	18.6	13	235	7.5																			22	306	11.7
6,000	10	289	17.9	19	283	17.2	12	294	22.4	15	295	13.2	14	311	22.0																						19	302	13.8
8,000				15	291	24.9	10	285	29.6	11	307	13.2	10	309	24.1																						13	305	14.6
10,000				11	294	29.3																																	

Altitude (meters) m. s. l.	El Paso, Tex. (1,196 m.)			Ely, Nev. (1,910 m.)			Grand Junction, Colo. (1,413 m.)			Greensboro, N. C. (271 m.)			Havre, Mont. (766 m.)			Jacksonville, Fla. (14 m.)			Las Vegas, Nev. (570 m.)			Little Rock, Ark. (79 m.)			Medford, Oreg. (410 m.)			Miami, Fla. (10 m.)			Minneapolis, Minn. (261 m.)			Mobile, Ala. (10 m.)			Nashville, Tenn. (194 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	28	259	2.0	28	184	2.7	27	331	1.5	27	294	2.8	26	280	1.5	25	325	2.1	28	91	1.8	25	318	1.2	24	137	1.4	27	315	1.7	28	297	3.4	25	8	0.7	27	303	2.3
500										27	287	3.8				25	309	3.9				25	319	2.4	24	148	1.9	27	303	1.8	28	298	4.0	25	338	1.6	27	290	2.3
1,000										27	283	5.2	26	260	3.6	25	294	5.7	28	108	1.7	22	280	3.2	24	147	3.8	27	279	3.6	24	311	3.9	23	298	3.6	27	279	3.6
1,500	28	262	2.4				27	322	1.6	27	291	6.5	26	265	7.0	23	280	7.9	28	176	2.4	20	301	4.7	24	166	5.3	24	276	6.0	21	301	5.0	20	308	5.3	24	295	6.4
2,000	27	268	3.2	28	178	3.6	27	276	0.2	25	290	9.1	24	273	6.9	21	283	11.4	26	189	4.0	19	313	7.5	23	181	6.6	19	271	11.3	17	312	8.2	18	294	7.9	20	298	9.9
2,500	26	273	4.8	28	195	5.8	25	227	1.5	23	291	13.4	23	286	7.6	21	279	13.6	26	195	4.4	15	307	11.4	22	193	7.4	19	272	13.2	15	314	10.0	18	292	10.6	20	299	12.6
3,000	25	279	7.3	24	217	2.7	24	249	3.1	23	288	17.2	21	285	8.1	20	276	15.8	24	211	3.9	15	308	12.3	20	202	6.4	17	275	15.4	13	310	10.0	17	288	13.0	18	294	13.2
4,000	20	272	9.4	16	224	7.3	18	271	5.6	22	289	20.1	18	297	13.4	17	273	19.7	18	262	5.8	11	291	14.0	18	201	5.8	14	275	17.0	11	307	15.8	15	281	16.6	14	293	16.2
5,000	18	284	13.6	14	228	9.7	16	279	7.9	19	283	25.4	17	296	13.7	14	285	21.6	18	255	8.2				16	201	6.0	13	263	19.6				10	284	15.5	12	298	19.6
6,000	16	279	18.7	10	228	5.8	13	302	10.6	18	286	29.4	15	303	12.6	11	281	25.8	18	252	13.0				13	243	6.4	11	264	25.1									
8,000										12	287	36.4	11	290	13.4				11	281	14.1				10	269	6.2												

Altitude (meters) m. s. l.	New York, N. Y. (15 m.)			Oakland, Calif. (8 m.)			Oklahoma Okla. (402 m.)			Omaha, Nebr. (306 m.)			Phoenix, Ariz. (344 m.)			Rapid City, S. Dak. (982 m.)			St. Louis, Mo. (181 m.)			San Antonio, Tex. (183 m.)			San Diego, Calif. (15 m.)			Sault St. Marie, Mich. (230 m.)			Seattle, Wash. (14 m.)			Spokane, Wash. (603 m.)			Washington, D. C. (10 m.)		
	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity	Observations	Direction	Velocity
Surface	25	301	5.6	25	157	2.0	18	295	1.8	28	308	2.9	28	138	1.2	27	343	3.7	25	308	2.6	27	59	1.5	28	242	2.9	17	289	2.7	25	291	1.0	25	128	0.7	26	300	3.9
500	25	296	5.6	25	156	4.2	18	291	2.0	28	311	3.9	28	146	1.5				25	304	4.0	27	35	1.3	28	216	2.8	17	295	2.5	25	92	1.9				26	297	5.2
1,000	23	308	8.9	21	173	4.2	16	278	3.8	26	327	5.3	28	154	2.0	27	346	3.7	21	294	5.5	23	304	0.5	23	166	2.8	16	348	2.6	24	145	2.9	25	155	2.1	25	288	5.1
1,500	22	315	8.9	19	176	5.5	16	291	5.6	23	310	7.6	27	162	2.2	27	326	4.4	20	299	8.2	19	275	3.4	22	172	2.4	14	356	6.7	22	175	5.1	21	180	4.3	22	293	7.7
2,000	17	311	10.2	17	184	6.9	15	312	7.9	18	312	8.3	24	185	3.1	26	310	5.7	17	305	10.3	16	260	4.2	18	205	1.7	12	356	8.2	20	192	5.3	20	215	5.1	19	295	9.8
2,500	16	301	11.7	14	204	5.8	15	306	10.0	16	318	11.5	21	225	2.9	24	308	8.1	15	309	13.2	13	270	5.9	18	224	2.5	11	347	8.1	19	187	4.9	16	215	5.8	18	296	12.5
3,000	12	304	13.7	11	221	3.7	14	309	11.9	15	317	14.6	21	235	4.4	22	299	8.9	15	303	14.4	11	290	10.1	17	255	4.6	11	346	10.0	19	191	4.7	15	221	5.3	16	292	13.8
4,000							12	305	15.7	13	310	18.2	18	257	7.1	21	305	12.1	13	303	19.0	11	291	18.1	13	250	8.7				15	199	4.7	13	221	6.4	15	292	18.9
5,000							12	304	16.9	12	317	19.1	16	269	11.7	20	308	14.3	12	302	23.8	11	290	20.2							12	193	1.8	12	239	6.9	12	287	18.1
6,000										10	322	21.4	15	269	14.2	18	306	14.7	11	296	25.1										11	228	1.2				11	286	24.6
8,000																12	325	18.6													10	265	2.9						
10,000																10	336	22.5																					

TABLE 3.—*Maximum free-air wind velocities (m. p. s.), for different sections of the United States, based on pilot-balloon observations during February 1941*

Section	Surface to 2,500 meters (m. s. l.) Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Between 2,500 and 5,000 meters (m. s. l.) Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station	Above 5,000 meters (m. s. l.) Maximum velocity	Direction	Altitude (m.) m. s. l.	Date	Station
Northeast [1]	35.8	WSW	1,810	12	Binghamton, N. Y.	52.8	SSW	4,700	8	Portland, Maine	69.2	WSW	10,190	12	Caribou, Maine.
East-Central [2]	44.2	WNW	2,050	17	Louisville, Ky.	68.0	WNW	3,520	18	Norfolk, Va.	84.0	W	9,000	15	Greensboro, N. C.
Southeast [3]	37.7	NW	2,320	18	Spartanburg, S. C.	46.2	WNW	4,700	15	Atlanta, Ga.	70.0	WNW	10,150	23	Atlanta, Ga.
North-Central [4]	40.2	NW	930	14	Bismarck, N. Dak.	46.4	NW	5,000	18	Minneapolis, Minn.	64.4	WNW	5,940	18	Madison, Wis.
Central [5]	42.7	NW	2,260	17	Moline, Ill.	56.0	WNW	5,000	18	Chicago, Ill.	67.5	WNW	9,730	17	Omaha, Nebr.
South-Central [6]	42.5	W	2,490	12	Big Spring, Tex.	50.8	WNW	4,310	12	San Antonio, Tex.	82.0	NNW	11,030	11	Houston, Tex.
Northwest [7]	30.0	S	2,480	5	Medford, Oreg.	33.0	WSW	5,000	26	Spokane, Wash.	59.0	W	18,200	1	Billings, Mont.
West-Central [8]	47.6	S	2,324	28	Ely, Nev.	55.5	SSW	4,340	28	Ely, Nev.	79.2	NW	9,920	9	Pueblo, Colo.
Southwest [9]	45.4	W	1,909	12	Roswell, N. Mex.	80.0	WNW	5,000	12	Winslow, Ariz.	91.6	NNW	9,820	9	Albuquerque, N. Mex.

[1] Maine, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, and northern Ohio.
[2] Delaware, Maryland, Virginia, West Virginia, southern Ohio, Kentucky, eastern Tennessee, and North Carolina.
[3] South Carolina, Georgia, Florida, and Alabama.
[4] Michigan, Wisconsin, Minnesota, North Dakota, and South Dakota.
[5] Indiana, Illinois, Iowa, Nebraska, Kansas, and Missouri.
[6] Mississippi, Arkansas, Louisiana, Oklahoma, Texas (except extreme west Texas), and western Tennessee.
[7] Montana, Idaho, Washington, and Oregon.
[8] Wyoming, Colorado, Utah, northern Nevada, and northern California.
[9] Southern California, southern Nevada, Arizona, New Mexico, and extreme west Texas.

WEATHER ON THE NORTH ATLANTIC OCEAN

By H. C. HUNTER

Atmospheric pressure.—The average pressure during February 1941 over those portions of the North Atlantic that are amply covered by reports at hand was everywhere less than normal, though over the northern and eastern Gulf of Mexico the departure was small. Near the coast of the Maritime Provinces and New England the departure was especially large, −7.8 millibars (−0.23 inch). For most parts of the ocean it is indicated that pressure averaged lower during the second than during the first half of the month.

The extremes of pressure in the available vessel reports were 1,034.5 and 960.4 millibars (30.55 and 28.36 inches, respectively). The high mark was noted late on the 3d, near 38° N., 24½° W., on the Portuguese S. S. *San Miguel*. The low mark was recorded on the American liner *Siboney*, about 10 a. m. of the 15th, when the vessel was slightly more than 200 miles west of Lisbon. In the western portion of the North Atlantic the lowest reading was noted by the United States Coast Guard cutter *Pontchartrain*, near 40° N., 58° W., early on the 24th, 970.2 millibars (28.65 inches).

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure (sea level) at selected stations for the North Atlantic Ocean and its shores, February 1941*

Station	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Lisbon, Portugal	1,016.2	−3.1	1,029	7	990	15
Horta, Azores	1,016.8	−4.2	1,032	1, 3	996	26
Belle Isle, Newfoundland	1,000.1	−6.0	1,019	13, 14	970	19
Halifax, Nova Scotia	1,005.1	−7.8	1,031	13	984	16
Nantucket	1,009.5	−7.8	1,028	13	981	7
Hatteras	1,013.9	−5.7	1,025	24	991	7
Turks Island	1,015.4	−3.2	1,018	1, 19	1,010	12
Key West	1,015.6	−2.7	1,022	10	1,001	9
New Orleans	1,018.0	−1.0	1,027	4	1,004	6

NOTE.—All data based on a. m. observations only, with departures compiled from best available normals related to time of observation, except Hatteras, Key West, Nantucket, and New Orleans, which are 24-hour corrected means.

Cyclones and gales.—Those portions of the North Atlantic which are covered by reports at hand seem to have been about as turbulent, on the whole, as during an average February. The second half was stormier than the first half, but during the 21st to 23d, as during a similar period, 11th to 13th, the ocean regions from which information has come seem to have been free from notable storms.

An important cyclonic system affected the western part of the ocean during the first week. It lay approximately along the Appalachian crest, extending over nearly the entire width of the United States, on the morning of the 2d, but was not then of much energy, nor did it intensify greatly during the first hours that it was moving eastward over Atlantic waters. By the morning of the 4th, however, when it was less extended, it showed considerable strength round its chief center, about 500 miles east of Nantucket, and the following morning's reports indicated a vigorous storm centered near Newfoundland, where it moved but slightly for 24 hours, then continued its northeastward advance. The Coast Guard cutter *Chelan*, near 40° N., 59° W., on the 4th recorded a wind force of 12 in connection with this storm.

A LOW that was more severely felt close to the eastern coast of the United States than the one just described was centered over the Carolinas on the morning of the 14th, then moved to a short distance east of Hatteras the next evening; to about 38° N., 67° W., on the morning of the 15th; and to a location not far to southeast of Nova Scotia on the evening of that day. Through the 16th and part of the 17th it was near southwestern Newfoundland, after which it united with a LOW which had followed it, and remained near the Gulf of St. Lawrence for several days, finally moving on to northeastward on the 23d. No information at hand indicates force-12 winds connected with this storm, but the American liner *Excambion* met a force-11 gale when between Bermuda and New York, near 33° N., 65° W., while two cutters considerably farther to eastward likewise reported winds of force 11.

During the final week of February a storm developed east of the South Atlantic States, showing moderate strength on the 23d when centered between the Carolinas and Bermuda, and on the following morning being remarkably vigorous when located about 600 miles to eastward of Nantucket. Thereafter it continued to move northeastward till lost to observation beyond southern Newfoundland. The cutters *Cayuga* and *Pontchartrain* reported force 12 and the cutter *Bibb* force 11, while under the influence of this LOW.

John L. Ford of the Weather Bureau, in charge of the meteorological detail on the *Pontchartrain*, has supplied an account of that vessel's meeting this storm, near 40° N., 58° W., as the cutter headed for New York. The following is extracted from his account:

Highest winds were estimated at 130 to 150 miles per hour. The pressure reached the lowest point, 28.65 inches (970.2 millibars), about 2:20 a. m., February 24. Winds of force 8 or greater covered the entire period from that time to 10 a. m. the 25th.

During the three hours preceding the passage of the cold front the winds were mostly from south-southeast, force 2 to 5, skies somewhat variable with rain showers and frequent distant lightning. At 2:15 a. m. the wind shifted from south-southeast, 4, to northwest, with gusts of 7, for about one minute, then dropped to west, 4. At 2:20 the wind shifted back to northwest with force from 10 to 12, but seldom less than 11. With this shift in wind heavy rain showers occurred, with severe lightning in the distant southwest. Soon sheets of spray were being carried through the air, making it impossible to see far. The wind continued at velocities over 100 miles per hour until about 5 a. m. At 6:10 a. m. the wind was north-northwest, 70 miles per hour. (The lower limit of force 12 is 75 miles per hour.) It was then light enough to make out a ragged strato-cumulus layer at 150 to 200 feet above the surface. Long heavy swells at the rate of 8 per minute were observed.

During the last days of February and the early days of March another strong storm caused high winds over parts of the western Atlantic. From the Gulf of Mexico, where this storm had shown comparatively little strength on the 25th and 26th, the center moved across Florida during the night of the 26–27th. It was not far to the eastward of Norfolk on the morning of the 28th, and to southeastward of Nantucket at the evening observation. One vessel reported force 11 wind as met about 170 miles to east-southeastward of Norfolk during the 28th.

Some information has been received of the great violence of a storm about the middle of the month over Spain, Portugal, and the waters adjacent to them. As early as the forenoon of the 13th pressure was quite low between the Azores and the Bay of Biscay. This storm center moved eastward and was close to the northwest corner of the Iberian peninsula during the night of the 14–15th, and in about the same position during much of the 15th.

Press dispatches indicate that ships at Lisbon in the Tagus River were injured and some small boats sunk, while 60 persons were sent to hospitals there, due to the storm's havoc. In Spain and Portugal altogether at least 102 persons died, while the damage reached millions of dollars, many crops and valuable trees being ruined. It was considered the worst storm for Portugal since 1848. Though northern Spain apparently felt more severe winds than the southern part of the peninsula, yet even at Gibraltar a freighter broke its moorings and was driven upon the beach.

Three instances of hurricane-force winds (12), noted by Coast Guard cutters over western North Atlantic waters, have already been mentioned. February's fourth instance was connected with this eastern waters storm, the American liner *Siboney* encountering such force during the 15th to westward of Portugal.

Fog.—The available information implies that there was less fog than had occurred during the preceding January; also in those areas where during late winter fog is usually met most frequently the reports indicate somewhat less than February normally brings.

Near the eastern coast of the United States, from Maine to the Carolinas, the fog reports all fall within the period from 7th to 15th inclusive. Two 5° squares of this stretch of coast, about in the latitude of Chesapeake Bay, furnished reports on 3 days each, exceeding all other North Atlantic squares.

Apart from this coastal strip the observations of fog were widely scattered geographically, while in point of time they were well distributed through the month.

OCEAN GALES AND STORMS, FEBRUARY 1941

Vessel	Voyage		Position at time of lowest barometer		Gale began, February	Time of lowest barometer, February	Gale ended, February	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
	From—	To—	Latitude	Longitude									
North Atlantic Ocean			° ′	° ′				*Millibars*					
Chelan, U. S. C. G.	On Station No.1		39 45 N.	59 00 W.	3	1p, 4	5	989.2	SSW	SW, 12	W	SW, 12	S-WSW.
Shenandoah, Am. S. S.	Norfolk	Port Arthur	28 18 N.	79 12 W.	6	7a, 7	7	1,001.7	S	SW, 8	SW	SW, 8	
Republic, U. S. A. T.	New York	Cristobal	36 02 N.	73 56 W.	7	1p, 7	7	989.5	SSE	SSW, 7	W	SSE, 10	SSE-SW.
Panama, Am. S. S.	do	Port au Prince	[1]36 00 N.	74 06 W.	7	2p, 7	7	987.5	SSE	S, 8	NW	S, 9	SSE-NW.
City of Omaha, Am. S. S.	Capetown	Savannah	30 54 N.	78 20 W.	6	2p, 7	7	995.3	SE	SW, 8	WNW	W, 8	SW-NW.
A vessel	New York	Puerto Sucre	33 44 N.	71 00 W.	7	5p, 7	7	995.3	S	S, 9	SW	S, 9	S-SW.
Coamo, Am. S. S.	do	San Juan	34 48 N.	71 45 W.	7	6p, 7	8	988.8	SSE	SSW, 7	W	SSE, 10	SSE-W.
William G. Warden, Am. S. S.	Baton Rouge	Boston	41 42 N.	69 18 W.	7	2a, 8	8	983.7	SE	SW, 8	WSW	E, 9	SE-WSW.
Chelan, U. S. C. G.	Bermuda	Station No. 1	35 36 N.	64 06 W.	7	2p, 8	8	1,004.7	SSE	SW, 5	SW	S, 10	
Hibueras, Am. S. S.	Puerto Barrios	New Orleans	22 15 N.	86 19 W.	8	8p, 8	9	1,004.7	WSW	S, 3	NNW	NNW, 8	NE-S-WSW.
R. W. Gallagher, Am. S. S.	Boston	Houston	25 06 N.	85 42 W.	8	11p, 8	9	1,003.7	NW	NW, 9	NNW	NW, 9	NW-NNW.
Pontchartrain, U. S. C. G.	On Station No.2		39 42 N.	45 12 W.	9	2p, 10	10	1,009.1	SSW	SW, 9	NW	W, 10	SW-W.
Do	do		38 42 N.	46 00 W.	13	4p, 13	14	1,006.4	NNE	E, 6	NE	NE, 9	NE-E.
Nebraskan, Am. S. S.	New York	Cristobal	32 42 N.	74 54 W.	14	2p, 14	15	1,001.7	S	WSW, 8	NW	WSW, 8	S-W.
Tennessee, Am. S. S.	Providence	Port Arthur	[1]38 42 N.	72 43 W.	15	4a, 15	15	999.0	NNW	NNE, 5	NW	NNW, 9	NE-NNW.
Siboney, Am. S. S.	Lisbon	San Miguel, Azores.	[1]38 28 N.	12 59 W.	15	10a, 15	17	960.4	S	WSW, 10	WSW	NW, 12	S-WSW-N.
Excambion, Am. S. S.	Bermuda	New York	[1]32 56 N.	64 58 W.	15	4p, 15	17	1,000.7	WSW	WSW, 9	NW	WNW, 11	WSW-WNW.
Chelan, U. S. C. G.	On Station No.1		38 28 N.	59 00 W.	14	12m, 16	17	992.9	SSE	WSW, 8	W	W, 11	WSW-W.
Pontchartrain, U. S. C. G.	On Station No.2		38 54 N.	45 54 W.	16	6a, 17	17	999.7	W	WSW, 7	WSW	SW, 8	SW-WSW.
R. W. Gallagher, Am. S. S.	Galveston	New York	34 18 N.	75 30 W.	17	1p, 17	18	998.6	WSW	W, 7	NW	NW, 9	WSW-NW.
Chateau-Thierry, U. S. A. T.	San Juan	Boston	35 00 N.	68 12 W.	17	7p, 17	19	989.2	WSW	WNW, 9	WNW	WNW, 9	WSW-WNW.
Monroe, Am. S. S.	New York	San Juan	33 18 N.	70 54 W.	17	7p, 17	18	998.0	SW	SW, 9	WNW	SW, 9	SW-NW.
Chelan, U. S. C. G.	On Station No.1		38 38 N.	59 10 W.	18	4a, 18	19	983.1	S	SW, 9	W	W, 11	S-SW.
Pontchartrain, U. S. C. G.	On Station No.2		39 06 N.	45 30 W.	18	8p, 18	19	1,004.7	SSW	S, 11	SW	S, 11	S-SW.
Chelan, U. S. C. G.	On Station No.1		38 18 N.	60 00 W.	20	2p, 20	21	999.0	W	W, 8	W	W, 10	None.
Bibb, U. S. C. G.	Norfolk	Station No. 2	38 30 N.	54 54 W.	20	2a, 21	20	998.6	WNW	WSW, 7	WNW	WNW, 9	W-SW.
Cayuga, U. S. C. G.	On Station No.1		39 00 N.	59 18 W.	24	1a, 24	25	972.9	SSW	SSW, 5	W	NW, 12	SSW-NW.
Pontchartrain, U. S. C. G.	Station No. 2	New York	39 42 N.	58 18 W.	24	2a, 24	25	970.2	SSE	NW, 12	NW	NW, 12	SSE-NW.

See footnotes at end of table.

OCEAN GALES AND STORMS, FEBRUARY 1941—Continued

Vessel	Voyage: From—	Voyage: To—	Position at time of lowest barometer: Latitude	Position at time of lowest barometer: Longitude	Gale began, February	Time of lowest barometer, February	Gale ended, February	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Direction and highest force of wind	Shifts of wind near time of lowest barometer
North Atlantic Ocean—Continued			° ′	° ′				*Millibars*					
Bibb, U. S. C. G	On Station No. 2		37 42 N.	46 12 W.	24	2a, 25	26	991.2	S	WSW, 7	NW	WNW, 11	WSW-W.
Exeter, Am. S. S	Lisbon	Bermuda	35 18 N.	39 42 W.	25	9p, 25	26	993.2	W	W, 8	WNW	WNW, 8	WSW-WNW.
Marques of Comillas, Span. S. S.	do	Havana	38 06 N.	31 54 W.	26	4a, 26	27	999.9	W	SW, 7	WNW	WNW, 8	SW-W.
Cayuga, U. S. C. G	On Station No. 1		38 36 N.	58 42 W.	26	9p, 26	27	1,004.1	WSW	W, 10	NW	W, 10	W-NW.
Borinquen, Am. S. S	New York	San Juan	37 00 N.	72 30 W.	28	7a, 28	[2] 2	990.5	NE	S, 9	WNW	S, 9	ENE-S-SW.
Gulfhawk, Am. M. S	Puerto la Cruz, Venezuela.	New York	36.28 N.	73 10 W.	28	12m, 28	[2] 2	992.2	W	NW, 10	NW	NW, 11	W-NW.
San Gil, Pan. S. S	Cristobal	Philadelphia	[1] 31 30 N.	75 00 W.	28	4p, 28	[2] 1	1,005.4	NW	NW, 8	N	NW, 9	
A vessel	Baltimore	Baracoa	33 12 N.	75 06 W.	28	7p, 28	[2] 1	1,003.1	NW	NW, 8	NW	NW, 8	
North Pacific Ocean													
Collingsworth, Am. S. S	Portland, Oreg	Shanghai	38 36 N.	134 54 E.	[3] 30	4p, 30 [3]	1	1,001.4	SSW	SSW, 10	NW	NNW, 11	SSW-var.-NNW.
Kyusyu Maru, Jap. M. S.	Yokohama	San Francisco	47 01 N.	157 08 W.	[3] 31	6a, 1	3	952.9	SSE	S, 8	SSW	WNW, 8	E-S.
Buenos Aires Maru, Jap. M. S.	do	Los Angeles	[1] 42 52 N.	163 41 W.	1	6a, 1	3	959.7	WSW	W, 9	W	WSW, 9	WSW-W.
Mauna Ala, Am. S. S	Seattle	Honolulu	45 27 N.	130 51 W.	2	1p, 3	3	985.1	E	S, 10	SSW	S, 10	SSE-SW.
Chirikof, U. S. A. T	Ketchikan	San Francisco	46 36 N.	129 30 W.	2	3p, 3	3	991.5	SSE	SE, 9	S	SSE, 10	
Waipio, Am. S. S	Hilo	Grays Harbor, Wash.	38 42 N.	134 54 W.	2	3p, 3	3	992.9	SSW	SSE, 5	S	S, 8	S-SE.
Mauna Loa, Am. S. S	do	San Francisco	28 48 N.	141 54 W.	3	4a, 4	5	998.6	SSW	NW, 7	NW	NW, 8	SW-NW-WNW.
Makiki, Am. S. S	do	do	34 00 N.	132 00 W.	5	5a, 5	5	993.2	WNW	WNW, 8	WNW	WNW, 10	None.
Arctic, U. S. S	San Francisco	Honolulu	34 30 N.	129 00 W.	4	9a, 5	5	995.9	SSE	SW, 8	SW	W, 9	S-WSW.
Maliko, Am. S. S	do	do	36 20 N.	125 45 W.	5	3p, 5	6	993.2	SE	SE, 8	SE	SE, 9	SE-WSW.
Huguenot, Am. S. S	Los Angeles	Seattle	40 40 N.	124 48 W.	5	4p, 5	5	996.3	SE	SE, 9	SE	SE, 9	None.
Chirikof, U. S. A. T	Ketchikan	San Francisco	[1] 41 53 N.	126 07 W.	5	8p, 5	5	991.9	SE	SE, 9	SE	SE, 10	
Arctic, U. S. S	San Francisco	Honolulu	33 00 N.	131 54 W.	6	11a, 6	7	1,004.4	SSW	WSW, 7	SW	SW, 8	SSW-WSW.
Maliko, Am. S. S	do	do	34 12 N.	134 00 W.	7	3a, 7	7	1,003.1	WSW	SSW, 6	SW	SW, 9	SSW-WSW.
West Kyska, Am. S. S	Longview	Los Angeles	44 42 N.	124 24 W.	8	10a, 8	8	1,007.8	ESE	ESE, 7	SSE	ESE, 8	Steady.
Collingsworth, Am. S. S	Shanghai	Hong Kong	22 24 N.	115 12 E.	8	8a, 9	9	1,016.9	NNE	ENE, 6	ENE	NNE, 8	NNE-ENE.
Maliko, Am. S. S	San Francisco	Honolulu	31 12 N.	139 00 W.	9	9p, 8	9	1,007.5	SW	SSW, 5	W	W, 8	SSW-WSW.
West Kyska, Am. S. S	Longview	Los Angeles	42 54 N.	124 36 W.	9	5a, 9	9	995.6	SSE	SSE, 10	WSW	SSE, 10	SSE-WSW.
Winkler, Pan. M. S	San Francisco	Yokohama	[1] 30 37 N.	161 10 E.	8	6a, 9	9	1,002.4	ESE	SE, 8	NNW	W, 9	SE-SSW-NNW.
Mindanao, Phil. S. S	Manila	Los Angeles	31 12 N.	164 30 E.	9	2p, 9	9	1,002.0	S	SSW, 5	SSW	S, 8	SSW-NW.
Nemaha, Am. S. S	Los Angeles	Osaka	29 18 N.	170 00 E.	9	9p, 9	9	1,008.8	SSE	S, 9	S	S, 9	S-W.
Winkler, Pan. M. S	San Francisco	Yokohama	[1] 31 36 N.	153 48 E.	10	4a, 11	11	1,009.5	SSE	WSW, 7	N	NW, 8	S-NW.
West Kyska, Am. S. S	Longview	Los Angeles	37 18 N.	122 24 W.	10	9a, 11	11	988.8	SE	SW, 8	WSW	SSE, 10	NE-SW.
Collingsworth, Am. S. S	Hong Kong	Manila	19 24 N.	116 24 E.	11	8p, 11	12	1,014.6	NE	NE, 7		ENE, 8	
Capillo, Am. S. S	Dahican, P. I	Honolulu	43 06 N.	171 42 W.	11	6a, 12	14	984.4	SW	ENE, 5	SSW	S, 9	ENE-NNW.
Nitiei Maru, Jap. M. S	Konmon, Japan.	Los Angeles	46 51 N.	173 25 W.	13	12m, 13	13	970.2	SE	S, 9	SW	S, 9	SSE-SSW.
California Standard, Pan. M. S.	Estero Bay	Yokohama	34 58 N.	178 35 E.	12	12m, 12	13	999.3	S	W, 8	W	W, 10	WSW-W.
Do	do	do	35 04 N.	174 50 E.	13	6a, 14	15	994.2	SW	SSW, 10	W	SSW, 10	SW-SSW-W.
Kamakura Maru, Jap. M. S.	San Francisco	Honolulu	28 36 N.	145 48 W.	16	2p, 16	17	1,011.9	NW	W, 7	NW	NW, 8	WSW-WNW.
Matsonia, Am. S. S	do	do	29 42 N.	142 36 W.	16	3a, 17	17	999.7	W	W, 8	NW	W, 9	
Neches, U. S. S	Pearl Harbor	San Diego	27 00 N.	138 30 W.	17	3p, 17	17	1,006.8		WNW, 8		WNW, 8	WNW-NW.
Winkler, Pan. M. S	Yokohama	San Francisco	35 00 N.	151 42 E.	20	2a, 21	21	998.6	SSE	SSW, 8	NW	S, 9	S-SW.
Waipio, Am. S. S	Portland, Oreg	Honolulu	35 00 N.	143 18 W.	21	8p, 21	21	1,007.1	S	S, 8	WNW	S, 8	S-WNW.
North Sea, Am. S. S	Seattle	Sitka	54 36 N.	130 42 W.	23	4p, 23	23	[4] 1,010.5	E	N, 9	N	N, 9	E-N.
Porter, U. S. S	Los Angeles	Pearl Harbor	[1] 27 42 N.	141 57 W.	26	7p, 26	27	1,000.3	SW	WNW, 11	NW	WNW, 11	W-WNW.
Hamakua, Am. S. S	Aberdeen, Wash.	Honolulu	31 24 N.	147 12 W.	26	2p, 26	27	1,001.0	WNW	WNW, 8	NW	WNW, 8	W-WNW.
Manoa, Am. S. S	Los Angeles	do	31 30 N.	128 48 W.	28	9p, 27	28	1,000.3	NW	W, 6	NW	NW, 8	S-WNW.
Maliko, Am. S. S	Honolulu	San Francisco	36 50 N.	125 55 W.	28	11a, 28	28	981.7	SE	SE, 9	WSW	SE, 9	SE-WSW.

[1] Position approximate. [2] March. [3] January. [4] Barometer uncorrected.

WEATHER ON THE NORTH PACIFIC OCEAN

By Willis E. Hurd

Atmospheric pressure.—The most interesting pressure feature on the North Pacific Ocean in February 1941 was the almost continuous presence of low barometer off the west coast of the United States. The condition was well reflected by the abnormally low average barometer on the coast itself. The mean at San Francisco, for instance, was 1,012.2. millibars (29.89 inches) which is 7.1 millibars (0.21 inch) below the normal of the month.

In the northern Pacific the Aleutian Low was unusually deep, and at Dutch Harbor the average pressure, 988.7 millibars (29.20 inches), was 13.7 millibars (0.40 inch) below the month's normal. This average is the lowest of record for February at the station since 1927. The lowest barometer reported on ship was 952.9 millibars (28.14 inches), read on the Japanese M. S. *Kyusyu Maru* on the 1st, near 47° N., 157° W. A similarly low reading was made at St. Paul Island on the 11th.

Pressures below normal occurred in all upper Pacific waters, down the American coast to the Tropics, and then westward to Honolulu. From Midway Island westward the barometer was abnormally high, with two anticyclonic crests, one near Midway Island and the other east of China.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, North Pacific Ocean, February 1941, at selected stations*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Millibars	*Millibars*	*Millibars*		*Millibars*	
Barrow	1,021.7	+1.7	1,054	21	991	5
Dutch Harbor	988.7	−13.7	1,014	26	954	10
St. Paul	992.5	−11.6	1.019	25	953	11
Kodiak	1,000.9	−2.2	1.021	20	962	1
Juneau	1,010.8	−2.4	1.026	13	980	4
Tatoosh Island	1,011.5	−4.4	1,023	2	992	28
San Francisco	1,012.2	−7.1	1,024	1	990	11
Mazatlan	1,012.8	−0.7	1,015	7, 15	1,009	8
Honolulu	1,016.6	−1.0	1,025	10	1,011	6
Midway Island	1,019.8	+4.2	1,032	8	1,009	2
Guam	1,013.2	+0.3	1,017	12	1,007	7
Manila	1,013.1	+0.9	1,021	2	1,009	28
Hong Kong	1,017.6	−0.4	1,031	1	1,011	20
Naha	1,020.0	+2.4	1,030	1	1,009	23
Titijima	1,018.4	+3.2	1,025	6	1,008	10
Petropavlosvk	998.1	−7.0	1,019	22	980	13

NOTE.—Data based on 1 daily observation only, except those for Juneau, Tatoosh Island, San Francisco, and Honolulu, which are based on 2 observations. Departures are computed from best available normals related to time of observations.

Cyclones and gales.—Although pressures were unusually low in northern waters of the Pacific, thus indicating the frequent passage of deep disturbances, only a moderate degree of storminess was evidenced by ships' observations from all central and western waters along the northern routes. The few gales reported in February 1941 from high latitudes far from the coasts were practically confined to the region between longitudes 150° W., and 175° E., to the northward of latitude 40°. These gales, of forces 8–9, occurred on the 1st, 2d, and 11th to 13th.

South of this area the westbound Panamanian tanker *California Standard* met stormy weather on the 7th near 35° N., 166° W., and on the 13th to 14th near 35° N., from the 180th meridian westward to about 170° E. The heaviest gales, force 10, occurred on the 12th and 14th. Between 175° E., and 150° E., midway along the routes from Yokohama toward Midway Island, stormy weather occurred on the 9th to 11th, the 16th and 17th, and on the 20th and 21st. The gales were 8 to 9 in force, and were accompanied by only moderately depressed barometer.

In the extreme northeastern part of the China Sea fresh northeast monsoon gales were reported for the 8th and 11th.

The stormiest part of the ocean was a triangular region between the United States coast and a point at about the 150th meridian, northeast of the Hawaiian Islands. Of the numerous disturbances that affected some part of this area on all days of February except the 23d to 25th, several, particularly early, in the middle of, and very late in the month, caused gales of considerable severity, rising to force 10 locally on the 2d, 3d, 5th, 9th, and 11th, and to force 11 in squalls on the 26th. Off the Washington coast force-10 gales occurred on the 2d and 3d. Close to the Oregon coast fresh to whole gales were encountered by ships on the 5th, 8th, and 9th, and near the California coast, on the 5th, 10th, 11th, and 28th. As the disturbance of the 11th was moving inland, the southbound American S. S. *West Kyska* had a south-southeast gale of force 10 in the early morning, followed a few hours later, a little south of the Golden Gate, by a southwest wind of force 8 and barometer depressed to 988.8 millibars (29.20 inches). The lowest barometer at San Francisco that day was only two-hundredths of an inch higher. In the storm on the 28th, close to the coast, the American S. S. *Maliko*, near 37° N., 126° W., with a southeast gale of force 9, had a barometer as low as 981.7 millibars (28.99 inches).

Most of the storminess of the middle and late periods of the month in California-Hawaiian waters occurred within the general region 25° to 35° N., 135° to 150° W. Here there were mostly fresh gales on the 16th, 17th, 26th, and 27th. On the 26th, however, the U. S. S. *Porter* had squally weather near 28° N., 142° W., with the wind rising at times to force 11.

In the Gulf of Tehuantepec only one norther-type wind, that of the 5th, was reported to have attained a force as high as 7.

Fog.—The open ocean was singularly devoid of fog. In near coastal waters, it was reported on the 1st in Chosen Strait; on the 2d to 5th and the 9th and 10th off the southern coast of California; and on the 11th near the tip of Lower California.

RIVER STAGES AND FLOODS

By BENNETT SWENSON

Precipitation amounts were abnormally high from Oklahoma and Texas westward to the Pacific Ocean, including most of the Great Basin, and river stages were high in most of this area with light to moderate flooding occurring at a few points, notably in Texas, Oklahoma, and California. The outstanding feature was the heavy rainfall in California, especially the southern part of the State. Los Angeles reported a monthly total of 12.42 inches, which was the second greatest February total of record and the fourth greatest for any month in 64 years. The winter total at Los Angeles for this year was 20.13 inches, exceeded only in the winter of 1889–90 with a 3-month fall of 24.99 inches. The winter total for the entire State was 22.59 inches, the wettest winter in 25 years.

In the remainder of the country, precipitation was well below normal, except in Florida where it was above normal. In the East-Central States the precipitation was decidedly deficient and river stages were unusually low. Indiana and Tennessee had the driest February of record; Kentucky and Ohio, the driest since 1895; other States such as Pennsylvania, West Virginia, Virginia, and Missouri had the driest in 20 to 40 years. In contrast to California, the precipitation in Oregon was below normal and Washington had the driest February since 1920.

North Atlantic drainage.—Unusually heavy rains occurred on February 7 in the Northeast Coastal States, the heaviest amounts being confined to extreme southeastern New York and western Connecticut. Amounts recorded at regular Weather Bureau stations for the 24 hours ending at 7:30 a. m. of the 8th were 3.07 inches at New York City and 1.90 inches at Hartford, Conn. Greater amounts undoubtedly fell in this area but such records are not available at this time. Severe local flooding resulted from this rain in the smaller streams of western Connecticut.

The average snow depth over the Connecticut River Basin as of March 15–16 was 15.1 inches with an average water content of 4.14 inches.

Precipitation was frequent but rather light in amount in the Susquehanna River Basin, the average being below normal for the month. At the end of the month the snow depth in the basin above Towanda, Pa., averaged 5.2 inches with a water content of 1.25 inches. In the basin below Towanda the average snow depth as measured on March 4 was two inches. High temperatures with rain over most of the watershed on March 3 reduced the snow

mantle considerably and resulted in a small increase to stream flow.

East Gulf of Mexico drainage.—Several rises occurred in the Pearl River during the month but flood stage was exceeded only once when the stage at Jackson, Miss., reached 18.1 feet on February 8.

Upper Mississippi Basin.—Stages in the Rock River were slightly above flood stage at Moline, Ill., from February 15 to 17.

Red River Basin.—Minor floods occurred in the Sulphur River during the first week of the month and again in the last week. The crest stages in the first rise were 24.5 feet at Ringo Crossing, Tex., on the 3d and 24.9 feet at Naples, Tex., on the 7th. In the second rise the crest at Ringo Crossing was 22.5 feet on the 27th, but the crest had not reached Naples at the close of the month. The total losses have been estimated at about $3,200.

West Gulf of Mexico drainage.—The streams in eastern Texas remained at moderately high stages during the month as the result of abundant rainfall. Minor flooding occurred in the Trinity and Guadalupe Rivers, but resulted in no damage of consequence.

Colorado River Basin.—The Salt River, which has been dry for several years, rose to a stage of 4.5 feet on February 22 and 5.2 feet on March 3 at Phoenix, Ariz. Advisory warnings were issued for these rises as it was necessary for several families who were living in the river bottoms to evacuate.

Pacific Slope drainage.—Heavy rains in California resulted in high stages and some overflowing of lowlands in the Central Valley of California. Accumulating run-off into the Tulare Lake Basin broke the levees of one reclaimed district and about 5,000 acres was flooded.

In the Sacramento River proper moderate flooding took place on February 11–13 and another flood began on the 28th. Like the two preceding months frequent rains during February intensified the flood situation. On February 10 a general rainstorm with exceptionally heavy rainfall amounts fell at intermediate elevations over all tributaries of the Sacramento River. The run-off was excessive from all of the lateral streams in Tehama, Glenn, and Butte Counties, while the flow above Redding was proportionately light. The peak stages in the American and the extreme upper Sacramento River approximated those of December 1940, while in the Feather-Yuba and in the Sacramento from Red Bluff to Knights Landing, the flow was considerably greater than had previously occurred this season.

Flood or danger stages were exceeded by 1 to 2 feet at points from Red Bluff to Knights Landing. At the latter point the 32.2-foot crest has been exceeded only twice in the history of the station. The water in the Yolo Bypass was unusually high but little additional damage resulted there because the island tracts have remained flooded since December 1940.

Toward the latter part of the month the lower San Joaquin began to rise moderately, and water flowing through unrepaired levee breaks of last year flooded limited areas of lowlands on the east side of the river north of the junction with the Stanislaus River.

The total losses from high water in the Sacramento Valley during February have been estimated at $463,000.

A moderate flood occurred in the Eel River from the 10th to 11th with a crest stage of 19.25 feet at Fernbridge, Calif., on February 11. The greatest losses inflicted were those sustained by railroads and highways. A partial list of these damages indicated a loss of $50,000.

FLOOD-STAGE REPORT FOR FEBRUARY 1941

[All dates in February]

River and station	Flood stage	Above flood stages—dates		Crest	
		From—	To—	Stage	Date
EAST GULF OF MEXICO DRAINAGE	*Feet*			*Feet*	
Pearl: Jackson, Miss.	18	7	8	18.1	8
MISSISSIPPI SYSTEM					
Upper Mississippi Basin					
Rock: Moline, Ill.	10	15	17	10.3	16
Red Basin					
Sulphur:					
Ringo Crossing, Tex.	20	2	5	24.5	3
		25	(1)	22.5	27
Naples, Tex.	22	5	11	24.9	7
WEST GULF OF MEXICO DRAINAGE					
Trinity:					
Dallas, Tex.	28	2	4	31.3	3
		24	25	31.6	25
		28	28	28.05	28
Trinidad, Tex.	28	5	8	29.5	7
		25	(1)		
Long Lake, Tex.	40	9	9	40.1	9
Liberty, Tex.	24	27	(1)		
Guadalupe:					
Gonzales, Tex.	20	3	3	22.9	3
Victoria, Tex.	21	4	6	23.6	6
PACIFIC SLOPE DRAINAGE					
Sacramento Basin					
Sacramento:					
Red Bluff, Calif.	23	10	11	24.7	10
		28	(1)		
Hamilton City, Calif.	20	11	11	20.65	11
Knights Landing, Calif.	30	11	17	32.2	13
Eel Basin					
Eel: Fernbridge, Calif.	17.5	11	11	19.25	11

[1] Continued into following month.

TABLE OF FLOOD LOSSES AND SAVINGS, FEBRUARY 1941

River and drainage	Tangible property	Matured crops	Prospective crops	Livestock and other movable farm property	Suspension of business	Total loss	Total savings
MISSISSIPPI SYSTEM							
Red Basin							
Sulphur	$100			$75	$3,000	$3,175	$350
Guadalupe River							800
PACIFIC SLOPE							
Sacramento River	121,500	10,000	280,000	1,000	50,500	463,000	[1] 100,000
Eel River	[1] 50,000						2,500

[1] Incomplete.

CLIMATOLOGICAL DATA

CONDENSED CLIMATOLOGICAL SUMMARY OF TEMPERATURE AND PRECIPITATION BY SECTIONS

[For description of tables and charts, see Review, January, pp. 30-31]

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Section	Temperature: Section average	Departure from the normal	Monthly extremes: Station	Highest	Date	Station	Lowest	Date	Precipitation: Section average	Departure from the normal	Greatest monthly: Station	Amount	Least monthly: Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	44.1	−4.8	2 stations	72	[1] 1	Valley Head	17	[1] 9	2.78	−2.43	Highland Home	5.40	Muscle Shoals	0.54
Arizona	48.4	+2.5	Gila Bend	86	28	Alpine	−4	2	2.17	+.83	Bright Angel Ranger Station.	5.40	Yuma Valley	.29
Arkansas	40.8	−2.7	Portland	72	13	Devils Knob	7	8	2.92	−.49	Lutherville	6.35	Blytheville	.51
California	49.7	+1.7	3 stations	82	[1] 4	Bridgeport	−9	3	7.25	+2.63	Mount Wilson	24.61	Blythe	.28
Colorado	30.6	+3.4	Eads	76	28	Taylor Park	−30	27	.76	−.23	Wolf Creek Pass	5.77	3 stations	.00
Florida	55.5	−5.0	2 stations	85	[1] 17	Hilliard	20	10	3.55	+.39	Belle Glade	6.91	Vernon	1.47
Georgia	43.5	−5.1	Fargo	75	13	Blairsville	11	[1] 4	2.18	−2.70	Newnan	4.51	La Fayette	.90
Idaho	32.8	+4.7	Orofino	67	27	Island Park Dam	−18	13	1.20	−.56	Deadwood Dam	4.04	2 stations	.05
Illinois	28.1	−1.7	Mount Vernon	66	12	3 stations	−10	19	.75	−1.16	Mount Vernon	1.63	do	.15
Indiana	27.9	−2.6	Tell City	75	12	Whiting	−6	19	.76	−1.65	La Porte	2.70	Huntington	.10
Iowa	22.3	.0	Keokuk	59	12	2 stations	−18	19	.50	−.59	Lake Park	1.32	Cumberland	.07
Kansas	34.1	+1.1	St. Francis	72	28	Alton (near)	−2	28	.77	−.22	Pratt	2.14	Carbondale	.11
Kentucky	33.1	−3.9	Leitchfield	68	12	Lynch (near)	3	20	.66	−2.75	Lovelaceville	1.75	Greenup	.22
Louisiana	50.0	−3.7	New Orleans (Audubon).	79	13	5 stations	22	9	3.05	−1.51	Burrwood	5.45	Clinton	1.44
Maryland-Delaware	31.4	−1.8	2 stations	60	12	2 stations	−10	5	1.41	−1.62	Ocean City, Md	3.51	Keedysville, Md	.16
Michigan	21.7	+1.5	do	54	[1] 12	Mio	−27	10	1.32	−.32	Houghton	3.80	Lowell	.32
Minnesota	12.4	.0	Winona	45	12	Warroad	−33	18	.58	−.17	Pigeon River Bridge	2.01	Bagley	.05
Mississippi	45.3	−4.1	Port Gibson	77	13	Holly Springs	16	8	2.66	−2.23	Macon	4.58	Hernando	1.46
Missouri	32.7	−.4	Anderson (near)	66	12	2 stations	0	[1] 19	.58	−1.48	Anderson (near)	1.94	2 stations	.10
Montana	27.3	+5.2	2 stations	68	28	Westby	−26	21	.35	−.42	Hebgen Dam	1.30	Harlowton (near)	T
Nebraska	28.2	+2.0	do	69	[1] 11	Newport	−13	22	.51	−.19	Ord	1.29	Haigler	.07
Nevada	39.7	+5.7	Overton	87	[1] 10	Ventosa	−11	5	1.28	+.20	Charleston Ranger Station.	5.60	Mina	.00
New England	23.9	+1.2	2 stations	50	7	First Conn. Lake, N. H.	−20	11	2.02	−1.08	Mays Mill, Vt	4.03	East Barnet, Vt	.33
New Jersey	29.3	−1.3	do	53	12	2 stations	−5	6	2.47	−1.08	Long Branch	3.74	Layton	.63
New Mexico	39.7	+2.5	do	79	[1] 11	Eagle Nest	−23	4	.87	+.14	Lee Ranch	3.25	2 stations	.03
New York	22.6	+.1	4 stations	52	[1] 7	Wanakena	−26	10	1.94	−.75	Eden	3.80	Scio	.35
North Carolina	37.3	−5.4	Mount Gilead	68	12	Mount Gilead	−3	28	1.90	−2.14	New Holland	5.06	Asheville	.65
North Dakota	12.2	+2.6	Beach	57	28	Edmore	−40	19	.22	−.25	Cooperstown	.70	4 stations	T
Ohio	27.3	−2.1	Portsmouth	65	12	Millport	−6	10	.76	−1.85	Warren No. 1	2.05	Portsmouth No. 1	.14
Oklahoma	40.8	−.2	8 stations	75	[1] 12	2 stations	11	[1] 7	2.42	+1.00	Calvin	4.69	Kenton	.16
Oregon	39.4	+4.1	McKinley	75	22	Austin	−2	15	2.00	−1.20	Port Oxford	10.55	Arlington	.57
Pennsylvania	26.5	−1.9	Waynesburg	62	13	Kane	−14	10	1.04	−1.81	Neshaminy Falls	5.81	McConnellsburg	.10
South Carolina	41.8	−5.7	Kingstree	72	13	Caesars Head	11	9	1.81	−2.42	Camden	2.66	Greenville	.85
South Dakota	21.2	+2.2	Orman	65	28	2 stations	−28	19	.26	−.30	Canton	1.22	Reva (near)	T
Tennessee	36.4	−4.8	Loudon	67	[1] 12	Gatlinburg	5	23	1.02	−3.33	Milan	1.90	Madison	.51
Texas	49.1	−2.2	Presidio	87	15	Stratford	13	7	3.00	+1.22	Rio Medina	7.72	Friona (near)	.06
Utah	33.9	+3.9	St. George	69	[1] 11	Myton	−23	6	1.62	+.32	Mammoth Ranger Station.	5.12	Manila	T
Virginia	33.6	−3.6	Floyd	65	12	Mountain Lake	0	10	1.09	−2.00	Wallaceton	2.94	Dale Enterprise	.07
Washington	39.5	+5.1	Monroe	73	[1] 4	Stockdill Ranch	3	[1] 14	1.93	−1.86	Spruce	11.64	Sequim	.16
West Virginia	29.2	−4.1	Huntington	66	12	Seneca State Forest	−11	10	.96	−2.17	Pickens	3.37	Moorefield	.10
Wisconsin	17.6	+.6	2 stations	47	12	2 stations	−25	19	.72	−.49	Plum Island	2.10	Neillsville	.15
Wyoming	26.4	+4.2	4 stations	65	[1] 3	Eden	−30	8	.48	−.30	Triangle F Ranch	3.14	7 stations	T
Alaska (January)	1.9	.0	View Cove	54	19	Fort Yukon	−65	27	2.05	−.09	Little Port Walter	26.21	Nenana	.00
Hawaii	68.1	−.1	2 stations	89	[1] 1	Haleakala (Maui)	18	9	2.65	−4.89	Kukui	12.00	2 stations	.00
Puerto Rico	74.5	+2.0	do	94	[1] 8	Garzas	51	[1] 17	.85	−2.38	Orocovis	4.90	7 stations	.00

[1] Other dates also.

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with 0.01 inch, or more	Wind: Average hourly velocity	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.	°F.		°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
New England							26.7	+1.3										72	1.70	−1.7										4.9		
Eastport	75	67	85	29.64	29.73	−0.25	25.6	+4.1	40	8	32	−1	10	19	31	23	18	71	0.40	−3.0	5	12.6	nw.	49	e.	8	9	7	12	5.5	1.9	T.
Greenville, Maine	1,070	6		28.58	29.79		16.6		40	8	27	−10	10	6	41	14	11		1.44	−1.3	8		nw.				9	3	16		4.4	20.0
Portland, Maine [1]	103	5	25	29.67	29.79	−.23	24.4	+.6	42	22	34	−2	6	14	37	21	15	70	3.07	−.9	5	7.9	w.	39	ne.	8	20	1	7	3.5	.3	T.
Concord [2]	289	54	72	29.50	29.82	−.22	25.2	+2.4	45	7	34	2	6	16	35	20	14	73	1.87	−1.0	5	7.6	nw.	24	e.	7	11	9	8	4.8	1.4	2.0
Burlington [2]	403	11	48	29.42	29.88	−.15	20.6	+1.2	42	7	28	−2	10	14	28	17	13	76	.88	−.7	8	9.6	n.	25	se.	14	7	9	12	6.3	4.2	T.
Northfield	876	12	60	28.88	29.87	−.17	18.6	+2.2	41	7	28	−10	10	9	38	13	10	85	1.41	−.8	6	8.7	n.	27	sw.	8	7	8	13	6.0	1.5	2.3
Boston [1]	124	33	62	29.68	29.82	−.22	29.4	+.6	47	8	36	8	10	22	25	25	18	65	1.70	−1.7	6	13.1	nw.	42	e.	7	10	8	10	5.1	1.3	T.
Nantucket	12	14	90	29.79	29.81	−.23	31.5	+.8	49	7	37	18	10	26	16	28	23	73	1.81	−1.6	10	15.6	w.	47	ne.	28	12	6	10	5.1	3.9	.8
Block Island	26	11	46	29.80	29.83	−.23	30.3	−.1	47	7	35	13	10	25	15	27	21	69	1.44	−2.2	6	20.2	nw.	45	se.	7	13	7	8	4.0	2.3	.8
Providence [2]	159	57	78	29.66	29.84	−.21	30.2	+1.2	49	7	38	9	10	22	26	24	18	68	2.34	−1.3	6	14.9	nw.	47	se.	7	14	5	9	4.6	1.2	T.
Hartford [1]	159	5	44	29.68	29.86	−.20	28.0	+.8	50	7	37	6	5	19	33	23	17	69	2.19	−1.6	6	10.9	n.	32	nw.	16	11	7	10	5.2	1.9	T.
New Haven [2]	107	5	39	29.75	29.87	−.20	29.8	+.8	50	7	36	10	10	23	23	25	19	70	2.66	−1.3	5	10.8	nw.	31	e.	7	13	9	6	4.2	2.0	.5
Middle Atlantic States							31.3	−2.1										62	1.75	−1.4										5.2		
Albany [1]	97	26	40	29.78	29.89	−.18	23.4	−.7	42	14	31	1	6	16	35	20	14	71	2.33	−.1	8	12.2	w.	35	w.	20	9	5	14	5.9	1.9	T
Binghamton	871	57	79	28.97	29.93	−.15	23.2	−.8	46	12	31	−7	10	15	40	20	16	77	1.21	−1.1	13	8.3	nw.	21	w.	19	5	3	20	7.3	7.8	.2
New York	314	415	454	29.53	29.89	−.19	31.4	+.1	52	7	38	14	10	24	24	26	17	59	3.31	−.5	5	18.3	nw.	47	nw.	16	13	8	7	4.6	3.4	2.0
Harrisburg [1]	374	94	49	29.54	29.96	−.13	29.4	−.8	48	25	37	14	10	22	30	25	18	67	.83	−2.1	5	10.2	nw.	26	n.	28	8	9	11	5.7	2.2	1.2
Philadelphia [2]	114	174	367	29.81	29.94	−.16	31.8	−2.1	50	12	38	16	28	25	19	26	21	73	2.08	−1.2	6	14.1	nw.	37	nw.	28	14	4	10	4.8	8.9	7.3
Reading	323	47	306	29.58	29.95		29.8	−.8	50	12	37	14	10	23	28	25	17	60	1.94	−1.5	5	14.5	nw.	37	n.	28	10	8	10	5.4	9.2	7.6
Scranton	805	72	104	29.04	29.93	−.15	25.6	−1.7	49	12	33	6	10	18	31				1.12	−1.9	8	8.0	nw.	24	nw.	25	7	7	14	6.3	4.1	1.3
Atlantic City	52	37	172	29.86	29.92	−.19	32.3	−1.3	45	7	38	17	10	26	21	27	20	64	3.09	−.2	7	16.6	w.	38	nw.	28	13	6	9	5.1	14.3	14.0
Trenton	190	89	107	29.71	29.92		30.4	−.3	48	12	37	14	10	24	23	26	18	62	2.16	−1.1	5	10.8	nw.	26	nw.	18	12	6	10	5.1	8.3	5.7
Baltimore [2]	123	100	215	29.82	29.96	−.15	34.0	−1.4	52	25	41	19	19	27	20	27	21	66	1.07	−2.3	5	12.6	nw.	41	sw.	18	14	6	8	4.6	4.8	3.0
Washington	112	62	85	29.84	29.97	−.14	33.8	−1.5	55	12	41	19	19	26	29	28	20	58	.92	−2.	6	9.4	nw.	35	nw.	18	12	8	8	4.4	2.0	1.2
Cape Henry	18	8	54	29.93	29.95		36.4	−4.8	50	17	41	25	5	31	24	33	28	72	2.58	−.6	8	15.4	n.	45	nw.	22	11	9	8	5.0	4.0	2.0
Lynchburg	686	144	184	29.24	30.00	−.11	36.2	−4.1	61	12	46	14	11	26	43	29	19	54	.75	−2.4	3	8.9	nw.	34	w.	17	14	7	7	4.2	1.4	.1
Norfolk [2]	91	80	125	29.87	29.97	−.14	38.0	−4.7	57	6	45	24	23	31	27	31	26	72	2.58	−.6	8	10.9	n.	32	nw.	18	11	7	10	5.1	5.7	3.5
Richmond [2]	144	11	52	29.82	29.98	−.13	36.1	−3.5	58	2	45	20	11	27	32	28	21	67	1.14	−2.0	6	8.9	nw.	30	nw.	17	13	9	6	4.2	3.3	2.0
Wytheville	2,304	49	55	27.52	29.99	−.13	29.6	−5.5	54	12	38	12	10	21	33	25	19	68	.84	2.2	8	8.8	w.	32	w.	17	11	8	9	5.1	2.8	.8
South Atlantic States							42.7	−5.2										66	2.11	−1.6										5.0		
Asheville	2,253	89	104	27.61	30.06	−.07	33.8	−4.7	58	12	43	16	10	24	36	27	20	62	.65	−2.5	3	10.8	nw.	28	nw.	18	10	7	11	5.5	1.1	0.4
Charlotte [2]	779	63	86	29.14	29.99	−.13	40.0	−3.9	62	12	50	22	9	30	31	31	23	62	1.67	−2.5	4	7.1	ne.	24	w.	17	10	10	8	4.9	2.8	.0
Greensboro	886	6	56	29.03	30.00		36.0		61	12	48	14	24	24	40	28	21	63	.84		3	8.6	nw.	31	w.	17	10	11	7	4.8	2.0	.0
Hatteras	11	5	50	29.93	29.94	−.17	41.2	−6.2	66	13	47	27	23	36	23	37	33	77	4.30	+.3	9	15.2	n.	45	nw.	23	12	5	11	5.6	T	T
Raleigh [2]	376	103	146	29.57	29.99	−.12	38.7	−4.5	60	12	49	21	20	28	35	31	23	62	1.14	−2.8	6	9.6	nw.	42	nw.	17	10	6	12	5.2	.8	T
Wilmington	72	73	107	29.90	29.98	−.14	42.4	−5.5	64	17	51	26	24	33	28	36	29	65	3.22	.0	7	9.4	nw.	30	w.	17	11	6	11	5.6	T	.0
Charleston [2]	48	11	92	29.94	29.99	−.13	45.5	−6.9	67	17	53	31	4	38	23	37	31	70	2.56	−.4	7	9.9	n.	27	w.	17	10	5	13	5.8	T	.0
Columbia, S. C. [2]	347	70	91	29.62	30.01	−.10	43.6	−4.6	64	13	54	25	10	33	31	35	28	65	1.80	−2.0	8	8.1	n.	25	w.	17	13	10	5	4.0	T	.0
Greenville, S. C	1,040	70	78	28.87	29.99		41.0	−2.3	60	15	51	22	8	31	32				.85	−4.3	4	7.0	ne.	26	sw.	7	14	6	8	4.4	T	.0
Augusta [2]	182	62	77	29.81	30.00	−.12	44.0	−5.9	65	13	55	24	10	33	35	36	27	59	1.82	−2.3	8	6.2	nw.	22	nw.	17	11	9	8	4.6	.0	.0
Savannah [2]	65	73	152	29.94	30.01	−.11	48.1	−5.9	69	17	58	31	8	38	29	39	32	69	2.04	−1.1	9	10.1	nw.	34	w.	17	11	7	10	4.9	.0	.0
Jacksonville [2]	43	86	110	29.98	30.02	−.10	51.2	−6.8	74	17	60	31	10	42	29	42	38	74	3.14	+.2	9	7.7	nw.	27	w.	14	10	8	10	5.2	T	.0
Florida Peninsula							63.0	−3.5										80	4.37	+2.5										5.7		
Key West [2]	21	10	64	29.97	29.99	−.08	66.8	−3.7	80	26	73	53	11	61	20	61	59	81	6.24	+4.9	10	10.5	n.	40	w.	9	8	11	9	5.2	.0	.0
Miami [2]	25	124	168	29.95	29.98	−.12	64.8	−2.3	82	25	73	43	10	57	26	57	55	83	3.75	+1.9	11	9.7	nw.	28	sw.	7	10	5	13	5.6	.0	.0
Tampa [1]	35	5	61	29.98	30.01	−.09	57.3	−4.6	74	13	66	38	10	48	27	50	46	75	3.11	+.6	10	11.8	n.	30	w.	3	7	11	10	6.2	.0	.0
East Gulf States							46.8	−5.4										71	2.91	−1.8										5.7		
Atlanta [1]	1,173	5	72	28.77	30.04	−.08	39.8	−5.5	60	12	49	23	9	30	30	33	25	60	1.91		8	11.5	nw.	32	nw.	28	10	6	12	5.6	T	.0
Macon [2]	370	79	87	29.63	30.03	−.09	43.9	−5.4	64	13	54	24	10	34	33	36	30	66	1.95	−2.5	10	7.7	nw.	23	nw.	28	10	5	13	5.7	T	.0
Thomasville	273	49	58	29.75	30.06	−.06	47.1	−7.9	70	13	58	30	10	37	35				2.85	−1.6	6		n.				9	4	15		.0	.0
Apalachicola	35	11	51	30.00	30.04		50.9	−5.3	72	17	59	34	10	43	29	45	41	76	2.42	−1.5	9	8.9	n.	28	s.	24	10	10	8	5.5	.0	.0
Pensacola	56	54	79	30.00	30.06	−.05	50.4	−4.8	68	17	58	29	9	43	27	45	39	69	3.23	−1.1	7	8.4	n.	25	se.	24	8	11	9	5.4	.0	.0
Anniston	741	9																														
Birmingham [2]	700	11	48	29.32	30.08	−.04	42.3	−5.7	63	12	51	23	9	34	27	35	29	68	2.91	−2.2	11	7.1	n.	22	se.	13	11	3	14	5.6	3.5	T
Mobile [2]	57	86	161	30.00	30.06	−.05	50.0	−4.7	68	18	59	28	9	41	26	44	39	76	4.21	−1.1	8	10.4	nw.	28	nw.	3	7	9	12	6.2	.0	.0
Montgomery [2]	218	92	105	29.83	30.07	−.05	45.6	−6.0	66	13	54	27	9	37	26	39	33	70	3.01	−2.4	10	7.5	n.	22	n.	3	10	6	12	5.7	T	.0
Meridian [2]	375	67	92	29.68	30.09	−.02	44.6	−5.0	65	12	54	25	10	36	33	39	35	76	2.37	−3.1	10	6.2	n.	18	nw.	13	12	5	11	5.5	T	.0
Vicksburg [2]	247	82	102	29.82	30.09	−.01	46.6	−5.2	74	13	54	30	9	39	28	39	34	76	3.16	−1.7	10	9.2	n.	25	w.	13	9	5	14	6.2	.0	.0
New Orleans [2]	53	76	84	30.00	30.06	−.03	53.3	−4.0	73	13	60	38	9	46	22	47	42	71	2.96	−1.3	7	7.5	ne.	21	e.	6	7	12	9	5.6	.0	.0
Port Eads, La	9	4	35																													
West Gulf States							50.2	−2.5										77	3.04	+0.5										6.9		
Shreveport [2]	249	92	227	29.82	30.09	.00	47.3	−3.6	70	12	55	31	7	39	29	41	36	72	3.84	+.6	10	11.2	ne.	36	s.	12	8	4	16	6.5	T	.0
Bentonville	1,303	12	51																													
Fort Smith	463	57	82	29.60	30.09	−.01	41.0	−1.8	67	12	49	20	8	33	35	36	30	69	3.65	+1.1	12	7.4	e.	29	nw.	13	7	6	15	6.5	6.5	.0
Little Rock [2]	357	94	102	29.73	30.12	+.01	41.0	−3.9	65	11	49	20	8	33	30	36	32	77	2.65	−1.2	13	8.4	ne.	29	nw.	13	8	3	17	6.6	3.3	.0
Austin [2]	605	68	90	29.42	30.07		51.0	−2.4	74	12	59	33	9	43	35	45	42	77	3.06	+.7	10	7.5	n.	29	sw.	12	5	6	17	7.1	.0	.0
Brownsville [2]	57	88	96	29.96	30.02		60.2	−2.4	82	13	67	38	9	54	24	55	53	86	1.13	−.1	9	10.6	nw.	34	se.	12	4	8	16	6.9	.0	.0
Corpus Christi [2]	20	11	78	30.03	30.05	.00	57.1	−1.3	75	13	63	38	8	52	21	52	50	88	4.80	+3.3	8	10.4	n.	37	s.	12	5	7	16	6.8	.0	.0
Dallas [1]	512	6	46	29.53	30.09		46.5		78	16	55	25	9	38	39	41	36	75	3.15	+.9	10	10.4	n.	45	s.	12	5	7	16	7.2	.0	.0
Fort Worth [1]	679	35	56	29.36	30.10	+.03	46.7	−1.6	78	16	55	29	7	38	35	42	37	76	3.42	+1.7	10	11.0	ne.	43	s.	12	4	7	17	7.4	.0	.0
Galveston [2]	54	106	114	30.00	30.06	−.01	53.9	−2.4	70	13	59	38	9	49	18	50	47	81	2.59	−.2	10	10.3	n.	26	e.	23	5	9	14	6.7	T	.0
Houston [2]	138	157	190	29.92	30.08		53.4	−2.5	73	16	60	33	9	46	25	47	43	77	3.06	−.1	9	10.7	nw.	31	s.	12	5	6	17	7.1	.0	.0
Palestine	510	64	72	29.55	30.09	+.01	48.0	−3.2	70	12	55	29	7	41	25	42	36	69	4.21	+1.2	10	7.9	n.	32	s.	12	5	8	15	6.9	.0	.0
Port Arthur	34	59	134	30.03	30.06		52.8		75	13	60	33	9	46	27				2.06	−1.5	7	13.0	n.	33	ne.	23	6	7	15	6.7	T	.0
San Antonio [2]	693	28	59	29.32	30.06	+.01	52.8	−2.6	77	12	62	30	9	44	35	48	45	79	1.86	+.2	7	8.5	ne.	26	s.	12	4	6	18	7.4	.1	.0

See footnotes at end of table.

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS—Continued

District and station	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max.+mean min.÷2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Departure from normal	Days with 0.01 inch, or more	Wind: Average hourly velocity	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
Ohio Valley and Tennessee	Ft.	Ft.	Ft.	In.	In.	In.	°F. 31.7	°F. −4.3	°F.	°F.		°F.		°F.	°F.	°F.	°F.	% 73	In. 0.86	In. −2.4		Miles								0-10 6.4	In.	In.
Chattanooga [1]	762	21	54	29.24	30.08	−0.05	37.7	−6.4	62	12	49	19	4	27	38	32	26	69	.62	-----	7	7.3	ne.	33	nw.	17	10	6	12	5.7	0.4	0.0
Knoxville [2]	995	66	84	28.98	30.07	−.05	36.6	−5.3	60	13	45	21	23	28	31	30	22	64	.87	−3.6	7	6.3	w.	25	w.	17	10	9	9	5.2	.8	.0
Memphis [2]	399	78	86	29.67	30.11	.00	40.0	−4.3	63	12	48	19	8	32	27	34	30	73	1.68	−2.7	7	8.6	n.	24	n.	28	7	9	12	5.6	4.9	.0
Nashville [2]	546	167	187	29.50	30.10	−.02	36.6	−5.0	60	12	44	19	8	29	27	31	25	68	.64	−3.5	7	9.8	nw.	35	s.	13	7	9	12	5.9	2.7	.2
Lexington	989	6	-----	28.99	30.10	−.01	31.2	−4.2	60	12	40	9	20	22	27	-----	-----	-----	.84	−2.8	8	-----	-----	-----	-----	-----	8	10	10	5.6	3.5	.3
Louisville [3]	525	106	120	29.51	30.09	−.02	32.8	−4.4	61	12	40	13	20	26	28	27	22	70	.45	−3.1	6	10.0	nw.	33	s.	13	9	8	11	5.5	1.0	T
Evansville [1]	431	76	116	29.67	30.10	−.01	31.8	−4.5	62	12	40	15	9	24	25	28	22	71	.70	−2.5	6	9.6	nw.	36	nw.	17	9	7	12	5.8	1.5	.0
Indianapolis [2]	823	98	129	29.15	30.07	−.03	28.1	−3.0	59	12	35	3	19	21	24	24	21	82	.66	−1.1	7	9.3	nw.	33	w.	17	6	6	16	6.9	5.1	T
Terre Haute [2]	575	68	149	29.46	30.11	-----	29.3	-----	60	12	37	5	19	22	25	25	21	78	.91	−1.7	8	10.7	nw.	37	nw.	17	7	7	14	6.6	5.4	T
Cincinnati [2]	627	11	51	29.37	30.08	−.02	30.4	−2.4	61	12	38	7	19	23	29	26	22	73	.64	−2.4	9	9.2	w.	33	w.	17	4	12	12	6.6	2.9	T
Columbus [3]	822	90	110	29.12	30.03	−.06	28.6	−2.1	57	12	35	6	19	22	22	24	20	77	.64	−2.0	11	11.4	w.	37	w.	17	2	8	18	7.7	3.2	1.0
Dayton [2]	900	186	213	29.06	30.06	-----	28.2	−3.2	58	12	35	5	19	22	24	24	21	82	.70	−2.0	10	11.3	w.	39	w.	17	4	9	15	7.2	2.1	T
Elkins [3]	1,947	61	78	27.90	30.03	−.07	26.0	−5.6	56	12	34	7	19	18	38	22	17	75	1.27	−1.8	13	7.5	w.	30	w.	17	3	8	17	7.6	14.4	4.6
Parkersburg	637	77	84	29.33	30.04	−.06	30.4	−3.8	60	12	38	11	19	23	31	26	20	69	1.25	−1.9	11	7.2	w.	31	w.	17	4	8	16	7.1	9.3	3.6
Pittsburgh [1]	842	39	54	29.07	29.99	−.10	26.0	−6.3	57	12	33	6	19	19	25	23	19	76	.80	−1.8	9	12.6	nw.	37	nw.	17	4	12	12	6.7	8.5	3.1
Lower Lake Region							24.1	−1.0										81	1.37	−1.0										7.3		
Buffalo [2]	768	243	280	29.08	29.95	−.11	23.6	−.7	47	13	29	7	10	18	23	21	18	83	2.05	−.9	17	16.7	w.	59	sw.	8	4	5	19	7.6	23.1	3.5
Canton	448	10	61	29.40	29.90	-----	18.5	+.5	49	13	27	−13	10	10	38	16	14	87	1.84	−.4	10	8.7	w.	31	sw.	8	7	8	13	6.4	10.6	1.8
Ithaca	836	77	100	-----	29.91		23.6	−.9	48	12	31	−3	10	16	35	-----	-----	-----	1.05	−.9	13	11.0	nw.	28	se.	13	6	1	21	7.8	18.8	1.0
Oswego	335	71	85	29.54	29.92	−.14	23.8	−.1	42	13	29	1	10	18	23	22	16	72	3.10	+.4	11	12.5	nw.	26	w.	19	2	7	19	7.9	27.2	12.0
Rochester [1]	523	5	69	29.35	29.94	−.12	22.5	−2.1	50	12	30	0	10	15	36	21	18	84	1.59	−1.1	16	12.7	w.	38	sw.	8	3	8	17	7.4	20.2	7.1
Syracuse [1]	506	5	51	29.25	29.93	−.14	21.7	−2.4	43	13	30	−7	10	13	39	19	16	83	1.98	−.7	14	11.2	sw.	31	sw.	8	4	5	19	7.7	15.6	2.7
Erie [2]	714	57	81	29.19	29.99	−.08	25.6	−1.3	49	13	31	10	10	20	24	22	20	86	1.28	−1.3	12	9.8	w.	27	w.	17	5	9	14	6.6	12.1	3.0
Cleveland [1]	762	27	54	29.15	30.00	−.07	26.6	−.8	55	12	32	10	19	21	23	23	20	81	1.35	−1.2	16	17.0	w.	51	w.	17	4	6	18	7.5	14.2	.7
Sandusky	629	5	67	-----	-----	-----	26.8	−.6	56	12	33	10	19	21	26	-----	-----	-----	.65	−1.5	10	11.0	sw.	28	w.	17	4	11	13	7.1	6.3	.0
Toledo [2]	628	79	87	29.31	30.02	−.05	25.8	−1.5	52	13	32	8	19	20	24	22	19	80	.66	−1.4	11	11.4	w.	30	w.	17	4	12	12	6.5	4.6	T
Fort Wayne [2]	857	69	84	29.08	30.04	-----	25.3	−2.3	53	12	32	0	19	19	24	22	19	81	.32	−2.0	8	10.4	w.	20	nw.	17	4	5	19	7.5	1.7	T
Detroit [1]	730	5	78	29.18	30.00	−.06	25.3	.0	50	13	32	7	18	19	23	22	18	76	.55	−1.6	8	11.8	nw.	31	sw.	8	4	8	16	7.2	4.2	.1
Upper Lake Region							21.1	+2.6										81	0.88	−0.9										7.3		
Alpena	609	5	89	29.27	29.97	−.06	20.5	+2.5	38	13	28	−9	10	13	41	19	14	77	.93	−.8	11	11.7	nw.	32	nw.	17	3	4	21	7.9	13.0	11.4
Escanaba	612	51	72	29.33	30.02	−.04	20.6	+5.2	38	13	28	1	18	13	22	19	16	83	.87	−.6	10	11.7	n.	38	n.	8	4	5	19	7.5	10.6	1.3
Grand Rapids [2]	707	70	244	29.22	30.01	−.04	24.7	+1.0	47	13	31	9	28	18	22	21	18	83	.65	−1.6	11	11.5	w.	30	w.	17	3	6	19	7.5	9.9	.4
Lansing	878	5	90	29.03	30.02	-----	23.4	+.5	48	13	31	1	10	16	29	21	19	88	.86	−1.0	12	9.9	nw.	25	nw.	17	5	6	17	7.3	9.3	1.3
Ludington	637	60	66	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Marquette	734	44	73	29.18	30.01	−.04	21.6	+5.3	39	13	27	5	19	16	20	20	16	80	1.22	−.7	16	10.1	nw.	26	nw.	8	1	8	19	7.9	11.1	12.0
Sault Sainte Marie [3]	614	11	52	29.27	29.97	−.06	18.4	+5.8	41	13	26	−8	28	11	31	16	13	85	1.23	−.7	13	8.6	nw.	33	nw.	18	4	3	21	7.9	17.5	14.0
Chicago	673	7	131	29.31	30.07	−.01	25.6	+.7	51	12	32	−5	19	19	23	23	19	76	1.01	−1.1	8	11.6	nw.	34	w.	17	9	1	18	7.0	11.2	.7
Green Bay	617	109	141	29.34	30.04	−.02	19.2	+1.8	42	13	27	−11	19	11	27	18	14	79	.67	−.9	8	11.1	w.	27	w.	17	5	6	17	7.1	8.7	2.8
Milwaukee [1]	681	33	66	29.28	30.05	−.01	23.0	+.2	43	12	30	−7	19	16	29	20	16	79	.63	−1.2	7	13.1	nw.	32	nw.	17	4	9	15	6.9	2.7	T
Duluth	1,133	5	47	28.81	30.09	+.01	14.4	+3.0	34	1	23	−21	18	6	31	13	9	79	.72	−.3	10	14.0	nw.	43	nw.	17	9	7	12	5.6	7.4	10.2
North Dakota							11.8	+3.9										84	0.17	−0.4										5.3		
Moorhead, Minn. [3]	940	50	58	-----	30.21	+.10	9.3	+1.2	35	1	18	−23	18	0	-----	-----	-----	91	.17	−.5	7	8.6	n.	27	nw.	13	9	9	10	-----	3.3	3.1
Bismarck [1]	1,677	4	41	28.32	30.21	+.09	15.2	+4.9	46	9	26	−24	27	5	40	14	10	77	.14	−.3	4	10.1	nw.	36	nw.	16	9	6	13	5.9	2.9	.6
Devils Lake	1,478	11	44	28.53	30.21	+.10	6.7	+1.6	34	1	15	−30	19	−2	29	7	5	93	.12	−.4	5	9.3	nw.	32	nw.	16	7	7	14	6.3	1.2	4.8
Lemmon, S. Dak.	2,602	4	38	27.32	30.17	-----	18.4	-----	53	4	31	−24	21	6	46	16	12	-----	.39	-----	4	-----	nw.	-----	-----	-----	12	4	12	-----	5.0	T
Grand Forks	832	11	71	29.26	30.22	-----	5.6	-----	34	1	16	−31	18	−5	29	5	4	-----	.53	-----	5	-----	nw.	-----	-----	-----	8	8	12	-----	5.8	16.7
Williston	1,878	42	50	28.11	30.18	+.07	16.0	+7.9	47	28	26	−21	21	6	39	14	10	75	.26	−.2	4	6.3	se.	27	nw.	16	14	7	7	3.8	3.1	3.7
Upper Mississippi Valley							24.2	−0.7										77	0.55	−1.1										5.8		
Minneapolis and St. Paul, Minn. [1]	919	32	61	29.09	30.14	+.05	14.8	−1.1	41	12	24	−20	19	5	37	12	8	76	.89	−.1	7	11.0	nw.	34	nw.	17	10	7	11	5.2	5.5	5.3
Springfield, Minn.	1,025	4	42	29.01	30.17	-----	16.4	-----	41	12	25	−13	19	8	37	15	11	-----	.78	-----	8	-----	nw.	-----	-----	-----	7	10	11	-----	3.8	1.3
La Crosse [2]	714	11	48	29.30	30.11	+.03	18.8	−.4	47	12	28	−15	19	10	32	15	11	79	.46	−.6	6	6.2	nw.	24	nw.	17	8	8	12	5.9	7.6	2.0
Madison [2]	974	70	78	28.98	30.09	+.02	19.6	+.5	42	12	27	−11	19	12	26	18	14	81	.37	−1.1	6	9.2	nw.	24	nw.	17	5	9	14	6.3	2.6	.6
Charles City	1,015	10	51	29.01	30.15	+.05	17.5	+.4	45	12	26	−14	19	9	29	16	12	83	.43	−.7	5	7.2	nw.	23	n.	13	10	10	8	5.2	4.2	.1
Davenport [2]	606	66	161	29.43	30.13	+.03	23.8	−1.1	51	12	31	−5	19	16	23	20	17	79	.45	−1.1	7	9.6	nw.	24	nw.	17	8	7	13	5.8	4.3	T
Des Moines [2]	860	5	99	29.18	30.14	+.03	24.2	+.5	49	12	32	0	19	16	27	21	16	76	.43	−.7	4	10.6	nw.	30	nw.	13	8	11	9	5.8	1.0	T
Dubuque	690	60	79	29.33	30.12	+.03	22.4	+.2	47	12	31	−10	19	14	27	20	14	72	.35	−1.0	7	7.5	nw.	26	nw.	17	10	5	13	6.1	3.5	.3
Keokuk	614	64	78	29.46	30.15	+.04	28.0	−.4	59	12	36	2	19	20	24	-----	-----	-----	.46	−1.1	5	8.1	nw.	33	nw.	17	8	9	11	5.8	.5	T
Cairo	358	87	93	29.72	30.12	.00	35.4	−3.1	60	12	43	16	8	28	26	-----	-----	-----	.71	−2.4	5	9.3	n.	27	se.	13	9	6	13	6.0	2.4	.1
Peoria [2]	609	11	45	29.43	30.11	+.01	25.7	−.2	57	12	34	−2	19	18	23	22	19	80	1.01	−1.0	7	7.4	nw.	25	w.	17	12	6	10	4.8	3.2	T
Springfield, Ill. [2]	636	5	191	29.40	30.11	+.01	29.1	−.4	59	12	36	5	19	22	26	24	20	80	.58	−1.8	8	11.2	w.	31	nw.	17	8	5	15	6.5	4.5	.5
St. Louis [3]	568	179	303	29.50	30.13	+.02	31.6	−3.2	62	12	40	11	19	23	28	27	21	68	.48	−2.1	6	11.3	nw.	40	s.	12	9	4	15	6.4	3.3	.3
Missouri Valley							27.8	+1.1										76	0.50	−0.8										6.6		
Columbia, Mo. [2]	784	6	66	29.27	30.14	+.03	32.2	+.5	61	12	40	13	19	24	31	27	21	70	.31	−1.7	6	8.0	nw.	28	nw.	16	5	10	13	6.6	1.3	T
Kansas City [1]	963	38	76	29.08	30.15	+.04	31.8	+.6	57	12	40	14	8	24	31	28	22	68	.58	−1.2	4	10.3	nw.	36	nw.	16	4	9	15	7.2	.5	.0
St. Joseph [2]	967	11	49	29.08	30.16	-----	30.2	+.6	54	5	38	12	8	22	27	26	23	80	.20	−1.5	6	8.9	nw.	30	nw.	13	5	9	14	6.9	.6	.0
Springfield, Mo. [1]	1,324	5	60	28.67	30.11	.00	34.0	−1.2	61	11	43	10	8	25	32	30	25	74	.96	−1.4	7	10.8	nw.	39	se.	12	4	8	16	7.2	7.1	T
Topeka	987	65	87	29.06	30.15	-----	32.2	+1.2	60	5	40	14	8	24	32	28	23	73	.33	−1.2	6	8.8	n.	33	nw.	13	5	7	16	7.1	1.7	.0
Lincoln [2]	1,189	11	81	28.84	30.17	+.07	27.4	+1.3	49	12	35	7	19	20	25	23	20	80	.78	−.2	8	9.3	n.	32	nw.	13	6	8	14	6.9	5.6	T
Omaha [1]	1,105	31	44	28.94	30.18	+.07	26.2	+.7	48	12	34	3	19	18	26	23	19	77	.59	−.3	5	10.7	nw.	40	nw.	13	6	8	14	6.5	3.7	T
Valentine	2,598	46	54	27.32	30.14	+.05	25.2	+3.8	55	11	36	−4	22	15	36	22	18	79	.44	−.1	8	8.3	w.	27	nw.	16	9	7	12	5.5	4.4	T
Sioux City [2]	1,138	64	106	28.90	30.18	+.06	22.0	+1.0	44	12	30	−7	19	14	30	20	16	81	.71	−.1	5	10.8	nw.	38	n.	13	6	6	16	6.6	2.3	.4
Huron [1]	1,301	26	41	28.73	30.20	+.08	17.0	+2.7	41	11	26	−12	19	8	32	16	12	76	.12	−.4	4	12.8	nw.	39	nw.	13	7	10	11	5.7	2.4	1.5
Northern Slope							28.4	+6.0										72	0.34	−0.3										5.5		
Billings [1]	3,570	18	39	26.32	30.08	-----	30.0	-----	64	28	42	1	23	18	42	25	17	65	.20	-----	4	11.4	sw.	29	sw.	28	7	12	9	5.5	5.2	.0
Havre	2,507	11	67	27.40	30.14	+.07	23.4	+9.8	54	5	35	−14	26	12	40	20	15	72	.18	−.3	5	8.0	e.	24	sw.	13	9	11	8	5.4	3.0	T
Helena [1]	4,124	5	35	25.78	30.12	+.01	27.8	+4.8	60	28	40	2	23	15	36	25	20	71	.15	−.5	4	6.1	w.	34	s.	28	7	11	10	5.8	1.3	.0
Missoula [2]	3,263	80	91	26.62	30.06	-----	34.9	+8.2	58	27	44	17	15	25	32	31	28	82	.63	−.2	5	5.9	se.	22	ne.	7	4	14	10	6.4	3.3	.0
Kalispell	2,973	48	56	26.93	30.07	−.01	28.8	+5.5	51	28	38	11	6	20	27	27	23	76	.50	−.6	2	4.1	w.	15	n.	23	7	8	13	6.1	4.6	.3
Miles City [2]	2,371	48	55	27.56	30.13	+.04	27.8	+11.0	65	28	40	−5	21	16	51	23	17	67	.22	−.3	5	6.3	ne.	22	nw.	12	7	14	7	5.4	3.7	.0
Rapid City [2]	3,259	50	58	26.64	30.13	+.05	27.8	+4.4	61	28	39	4	19	17	34	22	15	67	.08	−.4	2	7.3	n.	27	nw.	13	12	8	8	5.1	.8	.0
Cheyenne [1]	6,094	5	39	23.94	30.06	+.03	32.1	+4.8	59	28	44	5	7	20	40	26	18	62	.32	−.3	8	10.5	nw.	38	nw.	16	10	4	14	5.8	5.1	.0
Lander	5,352	60	68	24.63	30.10	+.02	25.4	+2.9	53	28	37	5	15	14	34	23	19	77	.66	.0	2	3.6	ne.	18	se.	11	10	9	9	5.1	6.3	.3
Sheridan [6]	3,790	-----	42	26.10	30.09	-----	30.2	-----	63	28	43	4	13	17	46	25	21	73	.10	−.6	4	6.3	nw.	29	nw.	25	11	9	8	4.9	2.6	.0
Yellowstone Park	6,241	12	46	23.84	30.17	+.07	26.3	+5.3	49	5	38	5	15	15	34	22	17	71	.58	.0	7	6.8	s.	25	nw.	12	9	9	10	5.6	7.5	2.1
North Platte [2]	2,821	11	51	27.10	30.13	+.06	30.2	+3.6	62	11	40	8	20	20	36	25	21	76	.36	−.2	5	7.5	nw.	28	n.	13	12	6	10	5.1	4.6	T

See footnotes at end of table.

CLIMATOLOGICAL DATA FOR WEATHER BUREAU STATIONS—Continued

District and station	Elevation of instruments			Pressure			Temperature of the air									Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation			Wind					Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Barometer above sea level	Thermometer above ground	Anemometer above ground	Station reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Mean max.+mean min.÷2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range				Total	Departure from normal	Days with 0.01 inch, or more	Average hourly velocity	Prevailing direction	Maximum velocity: Miles per hour	Maximum velocity: Direction	Maximum velocity: Date						
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.	°F.		°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles								0-10	In.	In.
Middle Slope							35.6	+1.8										73	0.93	+0.1										6.0		
Denver [2]	5,292	106	113	24.69	30.03	+0.02	37.2	+4.5	69	28	47	20	7	28	34	30	23	65	.15	-.4	5	6.7	s.	22	ne.	23	14	7	7	4.5	2.5	0.0
Pueblo [1]	4,690	5	36	25.25	30.02	+.02	37.0	+4.1	68	11	51	13	8	23	46	30	22	62	.26	-.2	3	7.6	e.	40	nw.	12	11	8	9	5.3	3.3	.0
Concordia	1,392	50	58	28.63	30.16	+.07	29.9	+.1	61	5	38	6	28	22	29	27	24	80	.89	.0	7	7.6	n.	30	n.	13	7	5	16	6.8	6.8	2.8
Dodge City	2,509	10	86	27.43	30.10	+.04	34.4	+1.2	64	12	44	13	20	24	38	30	25	75	1.37	+.6	10	10.0	n.	33	n.	13	8	5	15	6.6	7.5	1.0
Wichita [1]	1,358	6	64	28.64	30.12	+.04	34.6	+.2	61	5	44	16	28	25	35	30	27	79	1.09	-.2	9	13.7	ne.	50	nw.	13	10	2	16	6.3	4.5	.0
Oklahoma City [2]	1,214	10	47	28.79	30.11	+.04	40.4	+.8	70	12	49	20	8	32	31	35	31	76	1.83	+.7	11	8.7	n.	31	nw.	13	7	5	16	6.8	2.8	.0
Chadron, Nebr	3,439	5	44	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Southern Slope							47.6	+1.6										70	1.22	+0.5										6.3		
Abilene [2]	1,738	10	56	28.22	30.06	+.01	47.8	+.6	79	16	57	27	7	39	37	41	36	74	1.96	+1.0	9	8.9	n.	35	sw.	12	7	3	18	7.0	.0	.0
Amarillo [2]	3,676	10	49	26.26	30.04	+.02	40.8	+2.7	68	11	50	21	7	31	35	33	28	73	.94	+.2	10	9.3	se.	38	w.	12	9	8	11	5.9	6.2	.0
Del Rio	960	63	71	29.02	30.02	+.02	55.2	-.8	76	12	64	32	8	47	33	50	44	71	1.13	+.6	8	8.8	se.	24	nw.	10	6	9	13	6.6	1.6	.0
Roswell	3,566	75	85	26.36	29.99	+.01	46.4	+3.9	75	11	58	26	6	35	41	40	31	60	.84	+.3	5	7.5	s.	36	nw.	12	10	4	14	5.6	2.2	.0
Southern Plateau							48.1	+3.9										67	1.03	+0.5										6.1		
El Paso [2]	3,778	82	101	26.16	29.95	.00	53.0	+4.0	75	15	64	35	7	42	35	43	34	56	.46	.0	5	7.5	w.	26	w.	12	8	16	4	5.0	T	.0
Albuquerque [1]	4,972	5	34	25.03	29.98	-----	42.8	+2.3	65	28	54	23	6	31	37	36	28	62	.20	-.1	5	7.7	n.	40	w.	12	6	5	17	6.8	.5	.0
Santa Fe [2]	7,013	38	53	23.20	30.02	+.04	38.2	+5.1	57	28	48	18	2	29	33	32	27	73	.84	+.1	8	5.6	n.	21	w.	12	7	7	14	6.5	4.8	.0
Flagstaff	6,907	10	59	23.28	29.90	-.10	36.4	+5.6	60	28	46	14	1	27	34	33	30	78	1.77	-----	10	7.4	sw.	31	s.	11	4	13	11	6.3	4.0	.0
Phoenix [2]	1,107	39	87	28.80	29.95	-.04	58.8	+3.7	81	28	69	42	8	48	33	51	46	70	1.78	+1.0	9	5.3	e.	25	w.	11	5	6	17	7.0	.0	.0
Yuma	142	9	54	29.81	29.96	-.04	62.4	+3.8	80	11	74	43	8	51	30	54	46	62	.50	+.1	5	4.9	n.	28	w.	11	9	12	7	4.9	.0	.0
Independence	3,957	5	26	25.91	29.96	-.10	45.2	+3.0	64	2	56	27	7	35	34	39	32	---	2.40	+1.6	11	-----	s.	-----	-----	-----	5	4	19	-----	.0	.0
Middle Plateau							39.6	+6.1										73	1.34	+0.3										7.3		
Elko	5,077	5	36	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Reno [2]	4,529	61	76	25.37	29.92	-.16	41.8	+5.5	58	28	51	22	7	32	34	36	30	67	.89	-.3	8	5.4	w.	24	s.	28	5	8	15	7.1	T	.0
Tonopah	6,090	12	20	23.96	29.95	-----	38.7	-----	55	3	46	23	7	32	22	34	29	---	1.09	-----	10	-----	se.	-----	-----	-----	3	11	14	-----	1.2	.0
Winnemucca	4,339	5	56	25.54	29.94	-.15	39.7	+6.2	63	28	49	22	2	30	31	36	31	74	1.40	+.5	12	8.3	ne.	29	sw.	9	5	3	20	7.6	1.6	.0
Modena	5,473	10	46	-----	-----	-----	38.2	+7.2	59	28	48	15	4	28	31	-----	-----	-----	1.89	+.9	12	7.1	sw.	31	sw.	11	3	2	23	8.3	1.4	.0
Salt Lake City [1]	4,357	86	210	25.61	30.05	-.03	40.0	-----	62	28	48	20	3	32	24	35	32	82	1.57	+.1	13	5.5	s.	31	se.	11	4	8	16	7.1	.7	.0
Grand Junction	4,602	60	68	25.39	30.01	-.03	38.5	+5.6	50	28	47	16	3	30	27	34	28	70	.93	+.4	10	4.9	se.	28	ne.	11	5	12	11	6.2	T	.0
Northern Plateau							38.3	+5.3										79	1.02	-0.4										7.1		
Baker [2]	3,471	36	54	26.42	30.04	-.08	35.0	+6.0	51	21	43	19	15	27	26	32	30	84	1.31	+.1	9	5.5	se.	17	s.	6	2	11	15	7.2	7.2	.0
Boise [1]	2,739	5	49	27.16	30.04	-.08	39.4	-----	58	27	48	25	1	31	30	36	32	77	1.51	-----	13	8.5	se.	35	se.	9	6	5	17	7.2	T	.0
Pocatello [1]	4,478	5	31	25.46	30.08	-.02	32.2	-----	52	28	41	11	1	23	28	30	27	85	1.32	-----	13	6.1	e.	25	nw.	24	3	7	18	7.5	3.2	.0
Spokane [1]	1,929	27	42	27.95	30.02	-.07	38.4	+7.1	59	27	47	22	14	30	27	35	31	77	.83	-.9	9	4.4	e.	17	se.	1	6	6	16	7.0	2.0	.0
Walla Walla	991	57	65	28.92	30.01	-.10	40.2	+3.1	67	27	47	26	5	33	23	-----	-----	-----	1.10	-.7	8	4.7	s.	21	se.	28	5	4	19	7.3	2.2	.0
Yakima	1,076	58	67	28.84	30.01	-----	39.5	+5.0	56	21	48	25	16	30	28	36	31	72	.82	-.2	10	4.1	nw.	13	n.	14	8	5	15	6.4	.5	.0
North Pacific Coast Region							48.1	+6.2										74	2.58	-2.8										6.8		
North Head	211	5	56	29.64	29.86	-.20	50.0	+7.0	62	17	55	40	22	45	19	45	39	69	3.56	-3.9	15	14.1	e.	50	s.	1	7	2	19	7.0	.0	.0
Seattle [2]	125	90	321	29.78	29.91	-.15	48.2	+7.1	66	5	55	33	16	41	24	43	38	74	1.46	-2.4	11	7.4	n.	35	s.	1	10	1	17	6.5	.0	.0
Tacoma	194	172	201	29.69	29.90	-.16	46.2	+5.6	63	6	53	30	14	39	28	-----	-----	-----	1.70	-3.0	12	6.1	n.	34	sw.	1	7	4	17	7.0	.0	.0
Tatoosh Island	86	9	61	29.78	29.87	-.13	48.8	+7.8	64	4	53	37	23	45	13	45	41	76	5.31	-4.1	14	17.5	e.	46	e.	7	7	7	14	6.5	T	.0
Medford [1]	1,329	20	58	28.48	29.89	-----	47.0	+4.5	68	4	57	26	3	37	40	43	37	70	1.93	-.4	9	-----	se.	-----	-----	-----	4	10	14	6.5	.0	.0
Portland, Oreg. [2]	154	68	106	29.74	29.91	-.17	48.8	+6.7	61	21	56	36	25	42	23	43	38	76	1.45	-3.9	11	5.4	e.	16	e.	15	9	2	17	6.4	.0	.0
Roseburg	510	45	76	29.33	29.88	-.22	47.9	+4.5	67	27	57	32	7	38	31	45	41	79	2.63	-1.9	12	3.4	nw.	23	s.	9	1	10	17	7.9	.0	.0
Middle Pacific Coast Region							53.1	+3.3										77	7.62	+2.6										7.9		
Eureka	60	72	88	29.82	29.88	-.23	52.6	+5.4	71	4	59	39	25	46	23	49	44	75	6.68	+.2	15	7.7	se.	32	s.	5	2	5	21	8.1	.0	.0
Redding [1]	722	20	34	29.14	29.92	-----	51.2	+1.5	70	2	58	36	5	44	28	46	41	72	11.71	+5.1	22	6.9	nw.	36	se.	28	1	6	21	8.5	.0	.0
Sacramento [2]	66	92	115	29.85	29.92	-.17	53.1	+3.0	67	22	59	37	5	47	19	51	48	83	5.40	+2.4	15	7.6	se.	37	se.	28	4	9	15	7.4	.0	.0
San Francisco	155	112	132	29.72	29.89	-.21	55.4	+3.2	64	22	60	46	2	51	15	51	48	77	6.71	+2.9	19	7.5	e.	39	s.	28	1	10	17	7.7	.0	.0
South Pacific Coast Region							57.4	+3.5										77	7.59	+5.4										7.7		
Fresno [1]	327	5	35	29.60	29.96	-.12	53.6	+2.5	70	10	61	35	3	46	26	51	48	80	5.04	+3.6	13	4.9	se.	28	se.	11	0	4	24	8.9	.0	.0
Los Angeles	338	223	250	29.61	29.97	-.09	58.8	+3.3	77	4	66	45	7	52	25	53	48	72	12.42	+9.4	14	8.1	e.	36	s.	11	3	7	18	7.2	.0	.0
San Diego [1]	87	20	55	29.89	29.98	-.08	59.9	+4.8	79	27	68	48	5	52	26	55	52	78	5.31	+3.3	15	7.0	ne.	36	sw.	11	6	5	17	6.9	.0	.0
West Indies																																
San Juan, P. R	82	10	54	29.90	29.99	-----	77.6	+2.7	89	28	84	69	17	71	19	-----	-----	-----	.05	-2.7	3	8.4	se.	24	e.	26	19	7	2	3.4	.0	.0
Panama Canal																																
Balboa Heights	118	6	92	-----	[3] 29.83	-.03	82.6	+2.3	95	21	91	71	17	74	20	-----	-----	[3] 82	.53	-.1	6	8.6	nw.	26	n.	15	3	24	1	5.1	.0	.0
Cristobal	36	6	97	-----	[3] 29.85	-.04	81.9	+1.1	90	9	86	74	10	78	14	76	74	[3] 80	2.87	+1.4	15	13.2	n.	26	n.	15	3	11	14	7.1	.0	.0
Alaska																																
Fairbanks	454	11	87	[4] 29.33	[4] 29.88	-----	10.0	+10.8	44	15	23	-25	9	-3	36	11	5	69	.04	-.2	3	5.1	e.	25	ne.	21	13	5	10	4.5	.3	6.2
Juneau	80	96	116	[4] 29.85	[4] 29.94	-----	33.6	+3.4	55	4	38	14	25	29	22	31	23	66	1.56	-4.1	11	8.4	w.	45	se.	4	8	2	18	6.9	2.3	.0
Nome	22	5	59	-----	[4] 29.70	-----	15.2	+10.0	37	19	22	-24	1	8	-----	-----	-----	76	.69	-.2	12	14.3	ne.	53	n.	3	8	4	16	-----	6.3	2.5
Hawaiian Islands																																
Honolulu	38	86	100	29.98	30.02	-----	71.1	+.3	80	16	76	60	9	66	13	63	58	67	.48	-3.3	7	8.5	ne.	25	ne.	13	7	18	3	5.1	.0	.0

[1] Data are airport records.
[2] Barometric and hygrometric data from airport; other data from city office records.
[3] Observations taken bihourly.
[4] Pressure not reduced to a mean of 24 hours.
[5] Barometric data from airport records; other data from city office records.
[6] Wind, and clear, partly cloudy, and cloudy data, from city office records; other data from airport.

NOTE.—Except as indicated by notes 1, 2, 5, and 6, data in table are city office records.

SOLAR RADIATION AND SUNSPOT DATA FOR FEBRUARY 1941

SOLAR RADIATION OBSERVATIONS

By HELEN CULLINANE

Measurements of solar radiant energy received at the surface of the earth are made at 9 stations maintained by the Weather Bureau and at 10 cooperating stations maintained by other institutions. The intensity of the total radiation from sun and sky on a horizontal surface is continuously recorded (from sunrise to sunset) at all these stations by self-registering instruments; pyrheliometric measurements of the intensity of direct solar radiation at normal incidence are made at frequent intervals on clear days at two Weather Bureau stations (Madison, Wis.; Lincoln, Nebr.) and at the Blue Hill Observatory at Harvard University. Occasional observations of sky polarization are taken at the Weather Bureau station at Madison and at Blue Hill Observatory.

The geographic coordinates of the stations, and descriptions of the instrumental equipment, station exposures, and methods of observation, together with summaries of the data obtained, up to the end of 1936, will be found in the MONTHLY WEATHER REVIEW, December 1937, pp. 415 to 441; further descriptions of instruments and methods are given in Weather Bureau Circular Q.

Table 1 contains the measurements of the intensity of direct solar radiation at normal incidence, with means and their departures from normal (means based on less than 3 values are in parentheses). At Lincoln the observations are made with the Marvin pyrheliometer; at Madison and Blue Hill they are obtained with a recording thermopile, checked by observations with a Smithsonian silver-disk pyrheliometer at Blue Hill. The table also gives vapor pressures at 7:30 a. m. and at 1:30 p. m. (75th meridian time).

Table 2 contains the average amounts of radiation received daily on a horizontal surface from both sun and sky during each week, their departures from normal and the accumulated departures since the beginning of the year. The values at most of the stations are obtained from the records of the Eppley pyrheliometer recording on either a microammeter or a potentiometer.

Recalibration work is at present being conducted at all the stations measuring total solar and sky radiation, and from time to time there will appear in the MONTHLY WEATHER REVIEW information regarding any changes made necessary in the normals for the different stations. Recalibration has already been completed at the Massachusetts Institute of Technology, Cambridge, Mass., and corrected figures for that station for January will be found below under "Late Data."

Total solar and sky radiation was considerably deficient at Lincoln, Fresno, Twin Falls, La Jolla, and Riverside, and somewhat above normal at Washington, Madison, Chicago, New York, and Friday Harbor.

Normal incidence measurements at Blue Hill Observatory showed a considerable excess in radiation during both January and February.

TABLE 1.—*Solar radiation intensities during January 1941*

[Gram-calories per minute per square centimeter of normal surface]

Blue Hill Observatory

Date	7:30 a. m. 75th mer. time	Sun's zenith distance 78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	1:30 p. m. Local mean solar time
		Air mass A. M.					P. M.				
	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Jan. 1	3.0						1.35	1.24	1.13	1.03	3.2
Jan. 6	2.1							1.30	1.19	1.10	2.0
Jan. 7	1.0						1.43	1.30	1.18	1.08	1.3
Jan. 8	0.9	1.15	1.23	1.32			1.46	1.30	1.17	1.10	1.4
Jan. 13	1.8	0.98	1.02	1.18				1.26	1.15	1.07	2.1
Jan. 14	0.6	1.08	1.19	1.30			1.45	1.31	1.19	1.08	0.7
Jan. 20	1.0	0.75	0.87	0.96	1.37			1.00	0.88	0.79	1.4
Jan. 21	0.8		1.22	1.32	1.45			1.30	1.18	1.10	1.0
Jan. 31	1.9							1.20	1.04	0.94	2.1
Means		0.98	1.11	1.22	1.41		1.42	1.25	1.12	1.03	
Departures		+.02	+.07	+.07	+.10		+.10	+.08	+.08	+.09	

Solar radiation intensities during February 1941

Date	e	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e
Feb. 1	1.5	1.05	1.15	1.25	1.37						2.1
Feb. 4	2.2						1.29	1.16	1.04	0.92	2.3
Feb. 5	1.6	1.10	1.19	1.32	1.44		1.38	1.23	1.11	.99	1.8
Feb. 6	2.0	1.06	1.14	1.25							2.4
Feb. 8	4.0									.62	2.1
Feb. 10	0.8	1.08	1.18	1.30	1.41		1.38	1.21	1.07	.97	1.0
Feb. 11	2.1	0.93	1.05	1.13	1.38		1.19	1.00	0.88	.69	1.9
Feb. 16	1.2	1.07	1.18	1.30	1.46		1.45	1.29	1.16	1.04	1.4
Feb. 19	1.6	0.74	0.88	1.03							1.6
Feb. 20	1.5	0.86			1.30						2.0
Feb. 23	2.5	.92	1.03	1.13	1.29		1.30	1.18	1.06	0.95	2.6
Feb. 24	1.4	1.04	1.13	1.24	1.40		1.39	1.27	1.14	1.05	1.5
Feb. 26	1.1	0.95	1.07	1.20	1.36		1.34	1.15	1.00	0.91	1.3
Feb. 27	1.1	.93	1.04				1.38	1.13	0.98	.88	1.4
Means		0.98	1.09	1.22	1.38		1.34	1.18	1.05	0.90	
Departures		+.04	+.03	+.12	+.08		+.06	+.03	+.02	−.03	

*Extrapolated.

TABLE 2.—*Average daily totals of solar radiation (direct+diffuse) received on a horizontal surface*

[Gram-calories per square centimeter]

Week beginning—	Washington	Madison	Lincoln	Chicago	New York	Fresno	Cambridge	Fairbanks	Twin Falls	La Jolla	Newport	New Orleans	Riverside	Blue Hill	Albuquerque	Friday Harbor
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Jan. 29	204	247	183	125	195	152	182	27	249	334	203	241	317	188	285	105
Feb. 5	275	224	276	138	221	166	246	72	140	290	278	263	221	274	361	121
Feb. 12	241	208	221	146	194	242	188	69	218	233	216	383	223	199	361	279
Feb. 19	371	351	218	273	332	252	296	110	254	304	311	222	253	300	308	196
DEPARTURES FROM WEEKLY NORMALS																
Jan. 29	+2	+60	−37	+8	+38	−33	−9	−16	+55	+63	−9	+10	+78	−27	−11	0
Feb. 5	+6	+21	+16	+2	+57	−90	+30	+9	−56	−14	+34	+35	−58	+40	+19	+9
Feb. 12	+15	−16	−45	−1	+16	−44	−42	−12	−38	−58	−39	+28	−80	−34	+12	+124
Feb. 19	+112	+96	−64	+91	+125	0	+28	+6	0	−51	+26	−55	−82	+34	−34	+36
ACCUMULATED DEPARTURES ON FEBRUARY 25, 1941																
	+1,148	+364	−2,085	+392	+2,310	−1,659	+91	+112	−70	−1,239	+98	+1,232	−2,898	−455	−70	+1,344

LATE DATA AND CORRECTIONS TO TABLE 2

	Fairbanks		Cambridge*	
	Gram-calories	Departures	Gram-calories	Departures
Jan. 1	9	+8	139	+7
Jan. 8	17	+11	165	+18
Jan. 15	27	+16	119	−21
Jan. 22	38	+27	153	+1
Accumulated departures on January 28	+203		+42	

* The figures for Cambridge are 94.6% of the original figures.

POSITIONS, AREAS, AND COUNTS OF SUN SPOTS

[Communicated by Capt. J. F. Hellweg, U. S. Navy (Ret.), Superintendent, U. S. Naval Observatory.] All measurements and spot counts were made at the Naval Observatory from plates taken at the observatories indicated. Difference in longitude is measured from the central meridian, positive toward the west. Latitude is positive toward the north. Areas are corrected for foreshortening and expressed in millionths of Sun's hemisphere. For each day, under longitude, latitude, area of spot or group, and spot count, are included assumed longitude of center of the disk, assumed latitude of center of the disk, total area of spots and groups, and total spot count.

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1941	h m		°	°	°	°				
Feb. 1	11 7	8018	−39	293	−12	39	97	11	VG	U. S. Naval.
		8019	−31	301	+9	35	48	2		
		8018	−27	305	−12	27	218	5		
		8016	+2	334	−1	6	145	1		
		8015	+8	340	−10	9	6	3		
		8014	+21	353	+12	28	436	24		
		8020	+28	0	−10	28	24	3		
		8017	+76	48	−1	77	48	4		
				(332)	(−6)		1022	53		
Feb. 2	10 55	8021	−75	244	−15	75	12	2	G	Mt. Wilson.
		8018	−26	293	−12	27	97	11		
		8019	−19	300	+9	24	36	1		
		8018	−16	303	−11	16	218	6		
		8016	+8	327	−3	10	24	3		
		8016	+15	334	−1	16	121	1		
		8014	+34	353	+12	40	436	18		
		8020	+41	0	−11	41	48	6		
				(319)	(−6)		992	48		
Feb. 3	12 3	8022	−80	225	−9	80	194	1	VG	U. S. Naval.
		8021	−62	243	−15	63	12	1		
		8018	−12	293	−12	13	97	10		
		8019	−4	301	+10	16	36	2		
		8018	−1	304	−11	5	218	5		
		8016	+29	334	−1	30	97	1		
		8014	+49	354	+12	53	242	15		
		8020	+53	358	−12	53	24	3		
				(305)	(−6)		920	38		
Feb. 4	11 23	8022	−68	224	−9	68	121	1	F	Do.
		8025	−29	263	−10	29	24	3		
		8018	−1	291	−11	5	48	3		
		8019	+8	300	+10	18	24	2		
		8018	+12	304	−10	13	242	13		
		8024	+16	308	−4	16	6	1		
		8023	+23	315	+5	26	24	1		
		8016	+42	334	−1	43	73	1		
		8014	+64	356	+12	69	194	6		
		8020	+65	357	−12	65	48	2		
				(292)	(−6)		804	33		
Feb. 5	11 33	8026	−79	200	+14	80	145	4	G	Do.
		8022	−54	225	−10	54	73	3		
		8025	−14	265	−8	14	73	14		
		8018	+12	291	−11	13	48	3		
		8019	+20	299	+10	26	12	4		
		8018	+26	305	−11	27	145	11		
		8023	+38	317	+4	40	48	13		
		8016	+56	335	−1	57	24	2		
		8014	+78	357	+12	80	145	4		
		8020	+78	357	−12	78	12	1		
				(279)	(−6)		725	50		
Feb. 6	11 39	8026	−65	201	+14	70	121	2	F	Do.
		8026	−60	206	+14	65	121	4		
		8022	−40	226	−9	40	73	1		
		8025	0	266	−8	2	48	5		
		8018	+26	292	−10	26	48	1		
		8018	+40	306	−10	40	145	6		
		8023	+53	319	+4	56	24	4		
				(266)	(−6)		580	23		

POSITIONS, AREAS, AND COUNTS OF SUN SPOTS—Con.

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1940	h m		°	°	°	°	°			
Feb. 7	11 2	8026	−51	202	+15	56	73	3	G	Mt. Wilson.
		8026	−43	210	+15	49	12	2		
		8022	−27	226	−9	27	24	4		
		8025	+13	266	−9	13	48	4		
		8018	+40	293	−10	40	24	1		
		8018	+55	308	−10	55	145	8		
		8023	+67	320	+4	69	24	5		
				(253)	(−7)		350	27		
Feb. 8	11 22	8026	−37	202	+16	44	48	4	VG	U. S. Naval.
		8026	−27	212	+15	35	24	1		
		8022	−13	226	−9	13	24	1		
		8025	+28	267	−9	28	36	2		
		8018	+53	292	−11	53	6	1		
		8018	+68	307	−11	68	24	1		
				(239)	(−7)		162	10		
Feb. 9	10 55	8028	−82	145	−10	82	145	1	G	Mt. Wilson.
		8027	−44	183	+9	48	48	7		
		8026	−23	204	+15	32	48	5		
		8026	−14	213	+14	26	12	1		
		8022	−3	224	−7	3	12	3		
		8025	+41	268	−10	41	24	1		
				(227)	(−7)		289	18		
Feb. 10	10 50	8028	−68	145	−10	68	145	1	F	U. S. Naval.
		8027	−32	181	+10	36	48	2		
		8026	−12	201	+15	26	36	3		
		8026	−3	210	+15	23	12	1		
		8022	+11	224	−6	11	12	3		
		8025	+55	268	−9	55	6	1		
				(213)	(−7)		259	11		
Feb. 11	11 25	8028	−55	145	−10	55	97	3	F	Do.
		8027	−17	183	+9	24	24	3		
		8026	+12	212	+13	23	73	6		
				(200)	(−7)		194	12		
Feb. 12	10 52	8028	−42	145	−11	42	73	2	F	Do.
		8026	+27	214	+13	34	97	3		
				(187)	(−7)		170	5		
Feb. 13	11 30	8030	−58	116	+4	60	48	6	G	Mt. Wilson.
		8028	−28	146	−12	28	97	1		
		8029	0	174	+12	19	24	2		
		8026	+40	214	+13	45	121	10		
				(174)	(−7)		290	19		
Feb. 15	12 28	8031	−80	67	−3	80	48	1	F	U. S. Naval.
		8030	−25	122	+5	29	48	3		
		8028	−1	146	−12	5	97	1		
		8026	+71	218	+13	74	97	1		
				(147)	(−7)		290	6		
Feb. 16	12 2	8031	−68	66	−3	68	145	4	F	Do.
		8028	+12	146	−12	13	97	1		
				(134)	(−7)		242	5		
Feb. 17	12 3	8031	−55	66	−3	55	145	4	G	Do.
		8028	+25	146	−12	25	97	2		
				(121)	(−7)		242	6		
Feb. 18	12 21	8031	−47	60	−5	47	48	3	F	Do.
		8031	−40	67	−1	41	24	1		
		8028	+39	146	−12	39	121	2		
				(107)	(−7)		193	6		
Feb. 19	11 49	8031	−33	61	−5	33	36	3	G	Do.
		8031	−27	67	−2	28	12	1		
		(*)	+35	129	−13	35	97	11		
		8028	+52	146	−12	52	73	1		
				(94)	(−7)		218	16		
Feb. 20	12 1	8031	−13	68	−2	15	48	4	F	Do.
		(*)	+49	130	−13	49	145	6		
		8028	+65	146	−13	65	48	1		
				(81)	(−7)		241	11		
Feb. 21	11 3	8032	−77	351	+15	79	73	4	F	Do.
		(*)	+60	128	−15	60	48	3		
		(*)	+68	136	−13	68	121	1		
				(68)	(−7)		242	8		
Feb. 23	11 5	8032	−49	353	+17	54	291	5	F	Do.
				(42)	(−7)		291	5		

POSITIONS, AREAS, AND COUNTS OF SUN SPOTS—Con.

Date	Eastern standard time	Mount Wilson group No.	Heliographic: Difference in longitude	Heliographic: Longitude	Heliographic: Latitude	Heliographic: Distance from center of disk	Area of spot or group	Spot count	Plate quality	Observatory
1940	h m		°	°	°	°	°			
Feb. 24	12 1	8034	−70	318	+11	73	145	1	F	U. S. Naval
		8037	−57	331	+7	60	48	5		
		8032	−35	353	+17	43	339	5		
				(28)	(−7)		532	11		
Feb. 25	11 55	8034	−57	318	+11	60	242	2	VG	Do.
		8037	−43	332	+7	46	133	13		
		8032	−22	353	+17	33	436	16		
		(*)	−16	359	−9	16	12	2		
		(*)	−15	0	+15	27	24	4		
				(15)	(−7)		847	37		
Feb. 26	12 1	8034	−43	319	+11	47	291	2	G	Do.
		8037	−30	332	+8	34	145	5		
		8036	−20	342	+7	25	24	3		
		8032	−9	353	+17	26	485	9		
		8038	+40	42	−18	41	6	1		
				(2)	(−7)		951	20		
Feb. 27	14 24	8039	−78	270	+12	79	73	2	G	Mt. Wilson.
		8034	−29	319	+11	35	242	1		
		8037	−15	333	+ 8	22	97	19		
		8036	− 8	340	+ 7	17	12	7		
		8032	+ 7	355	+17	26	679	19		
		8038	+53	41	−17	53	12	2		
				(348)	(−7)		1,115	50		

Mean daily area for 25 days = 486

*=Not numbered.
VG=very good; G=good; F=fair; P=poor.

PROVISIONAL RELATIVE SUNSPOT NUMBERS FOR JANUARY 1941

Based on observations at Zurich and Locarno. Data furnished through the courtesy of Prof. W. Brunner, Eidgen. Sternwarte, Zurich

January 1941	Relative numbers	January 1941	Relative numbers	January 1941	Relative numbers
1	**a* 42	11	* 59	21	*a* 34
2	----------	12	*a* 28	22	**Mac* 40
3	----------	13	*a* 25	23	43
4	**Maac* 50	14	24	24	*d* 40
5	73	15	8?	25	44
6	74	16	*d* —	26	59
7	*Ecd* —	17	22	27	* 62
8	----------	18	*Ec* 29	28	*Ecd* —
9	*Wc* 58	19	* 12?	29	**Wc* 96
10	32	20	32	30	----------
				31	*b* 71

Mean, 24 days = 44.0

*=Observed at Locarno.
a=Passage of an average-sized group through the central meridian.
b=Passage of a large group through the central meridian.
c=New formation of a group developing into a middle-sized or large center of activity: E, on the eastern part of the sun's disk; W, on the western part; M in the central-circle zone.
d=Entrance of a large or average-sized center of activity on the east limb.

Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, February 1941

Chart I. Departure (°F.) of the Mean Temperature from the Normal, and Wind Roses for Selected Stations, February 1941

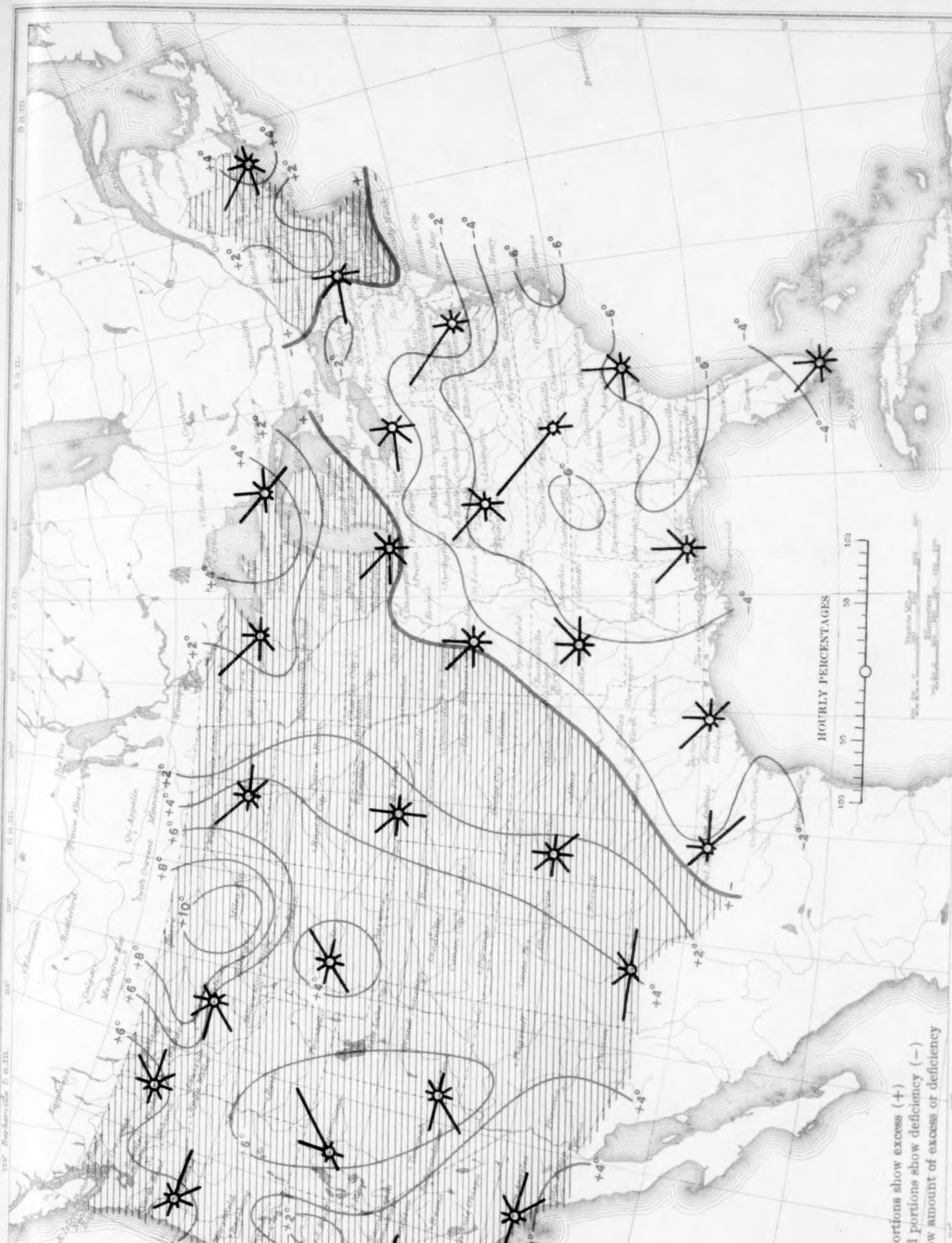
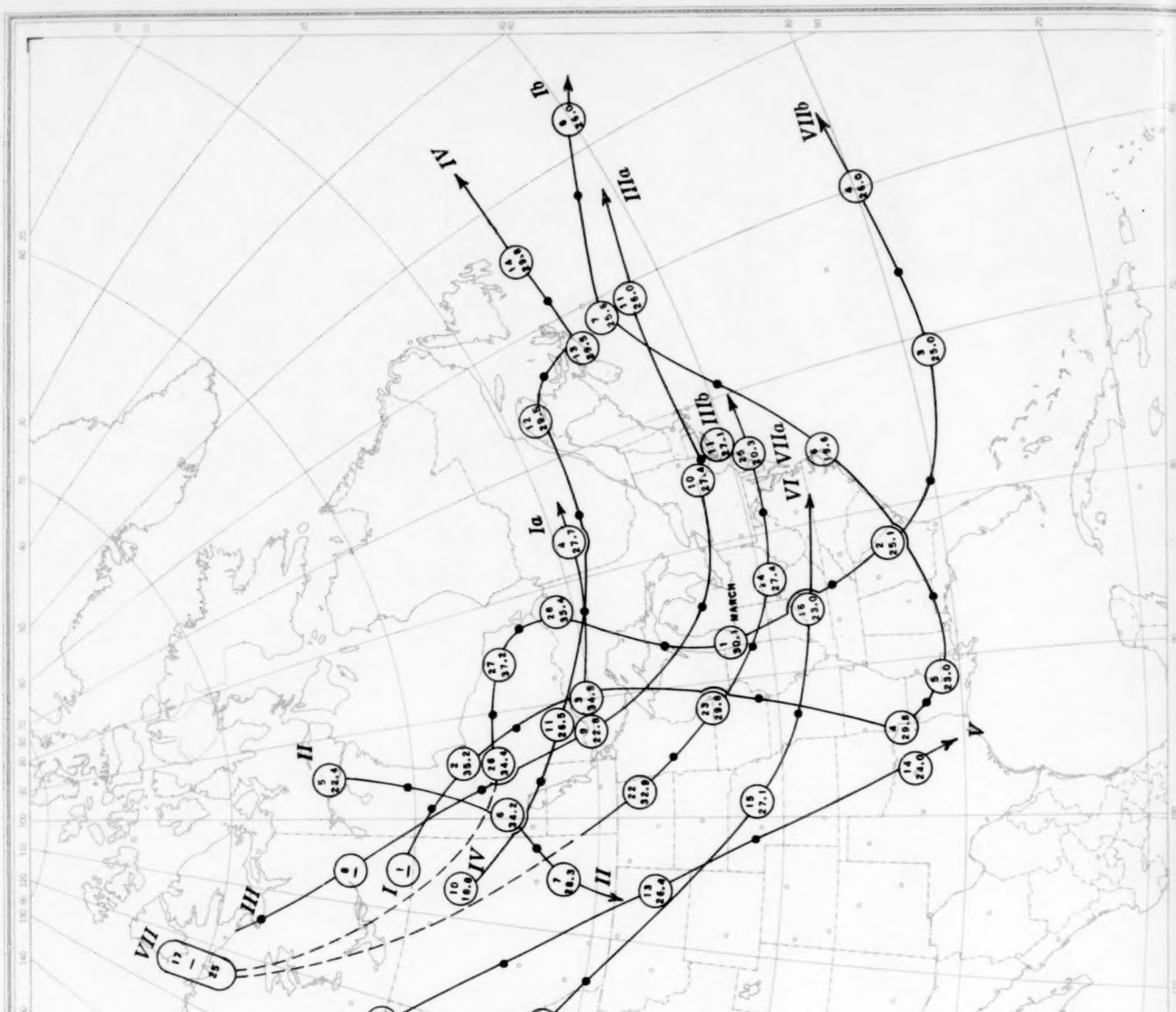


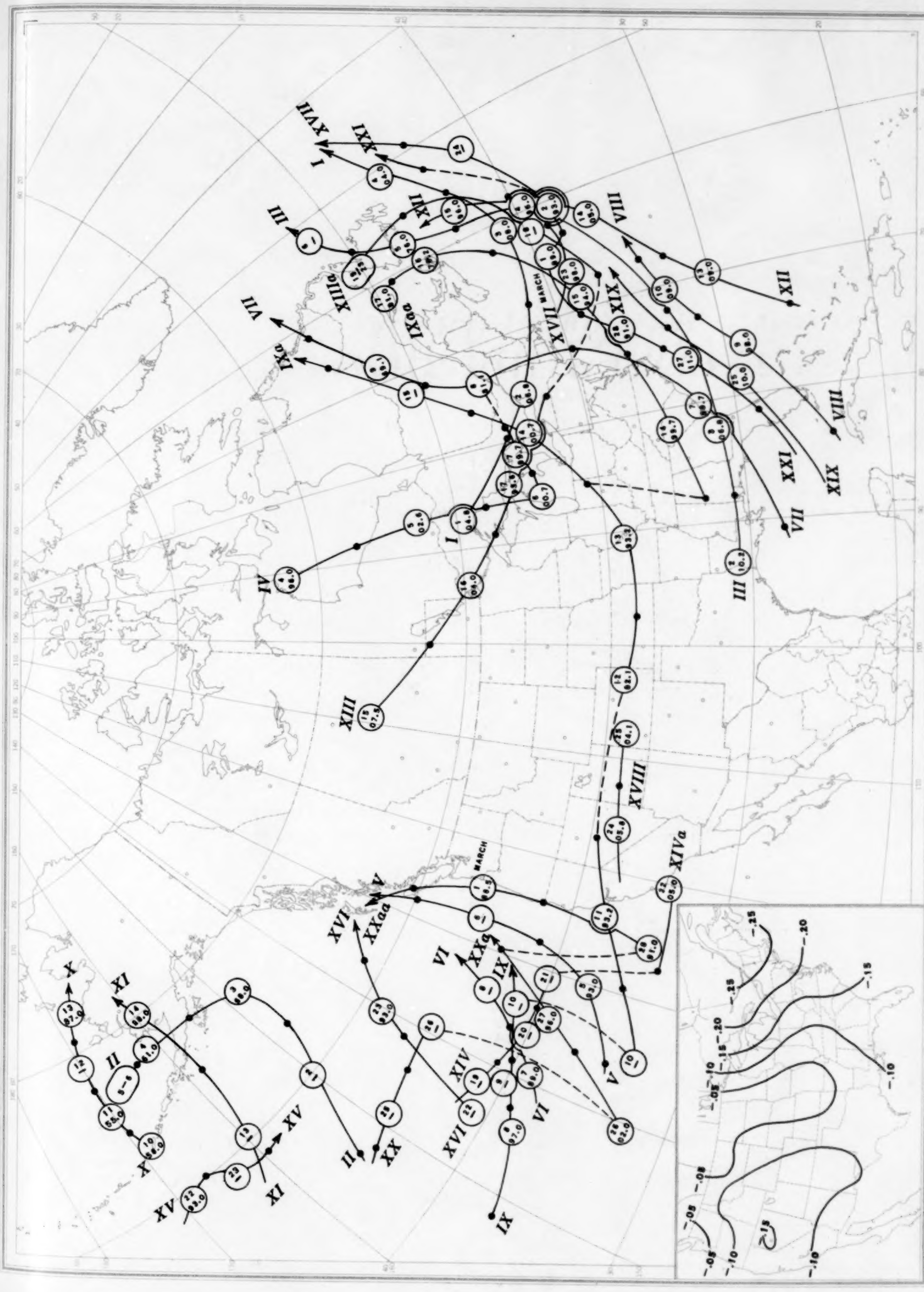
Chart II. Tracks of Centers of Anticyclones, February 1941. (Inset) Departure of Monthly Mean Pressure from Normal



Circle indicates position of anticyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of anticyclone at 7:30 p. m. (75th meridian time).

Chart III. Tracks of Centers of Cyclones, February 1941. (Inset) Change in Mean Pressure from Preceding Month

Chart III. Tracks of Centers of Cyclones, February 1941. (Inset) Change in Mean Pressure from Preceding Month



Circle indicates position of cyclone at 7:30 a. m. (75th meridian time), with barometric reading. Dot indicates position of cyclone at 7:30 p. m. (75th meridian time).

Chart IV. Percentage of Clear Sky Between Sunrise and Sunset, February 1941

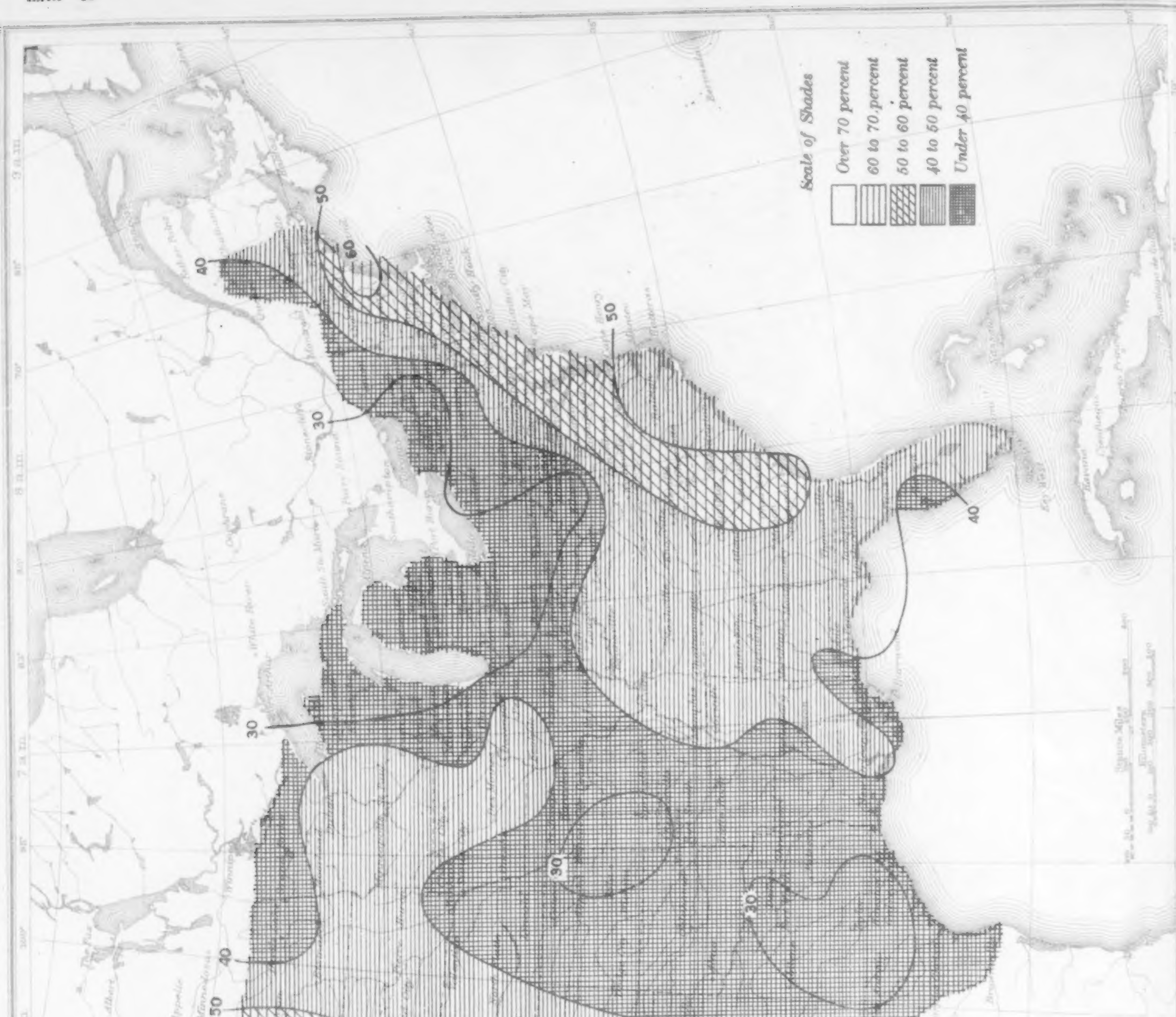


Chart V. Total Precipitation, Inches, February 1941. (Inset) Departure of Precipitation from Normal

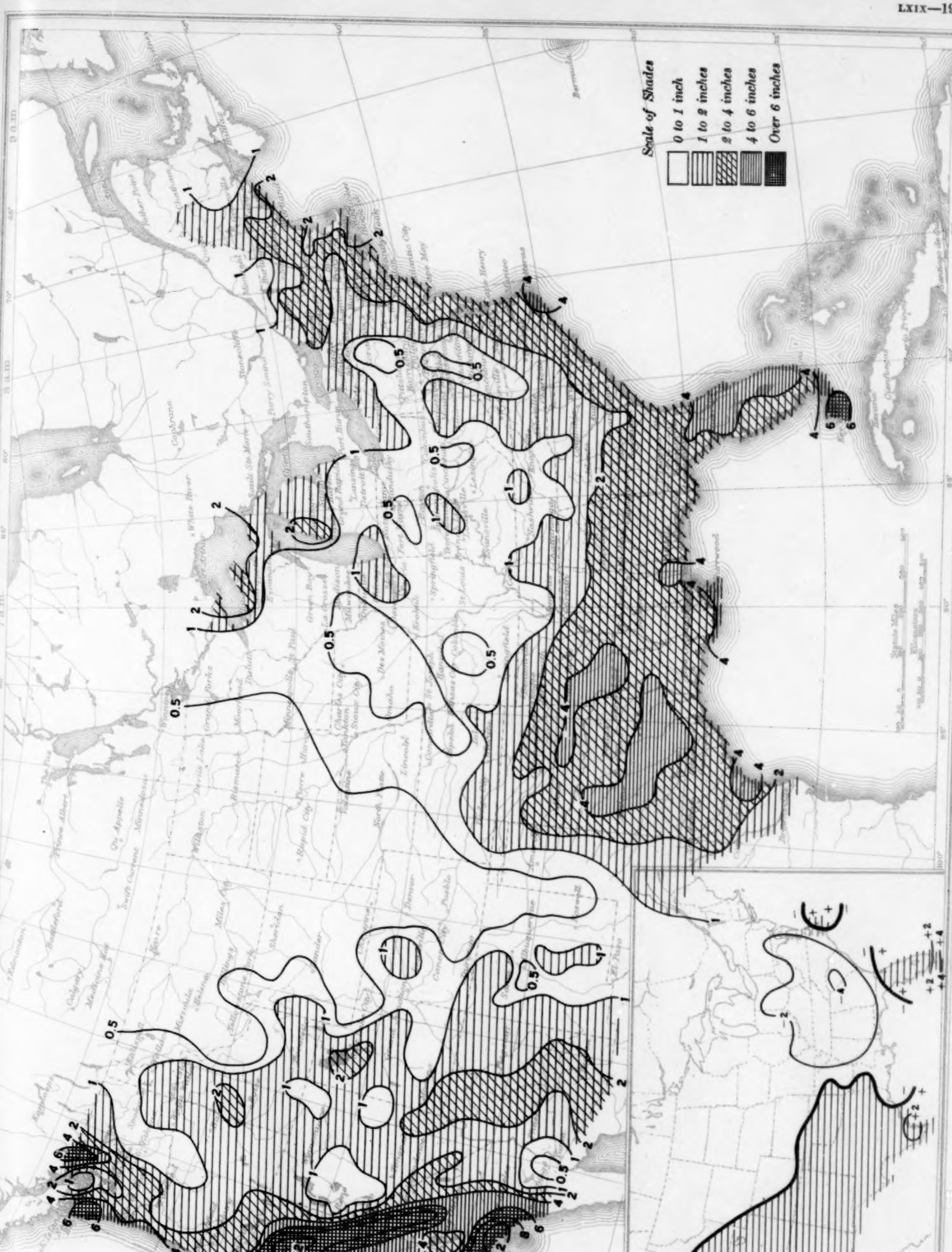


Chart VI. Isobars at Sea Level and Isotherms at Surface; Prevailing Winds, February 1941

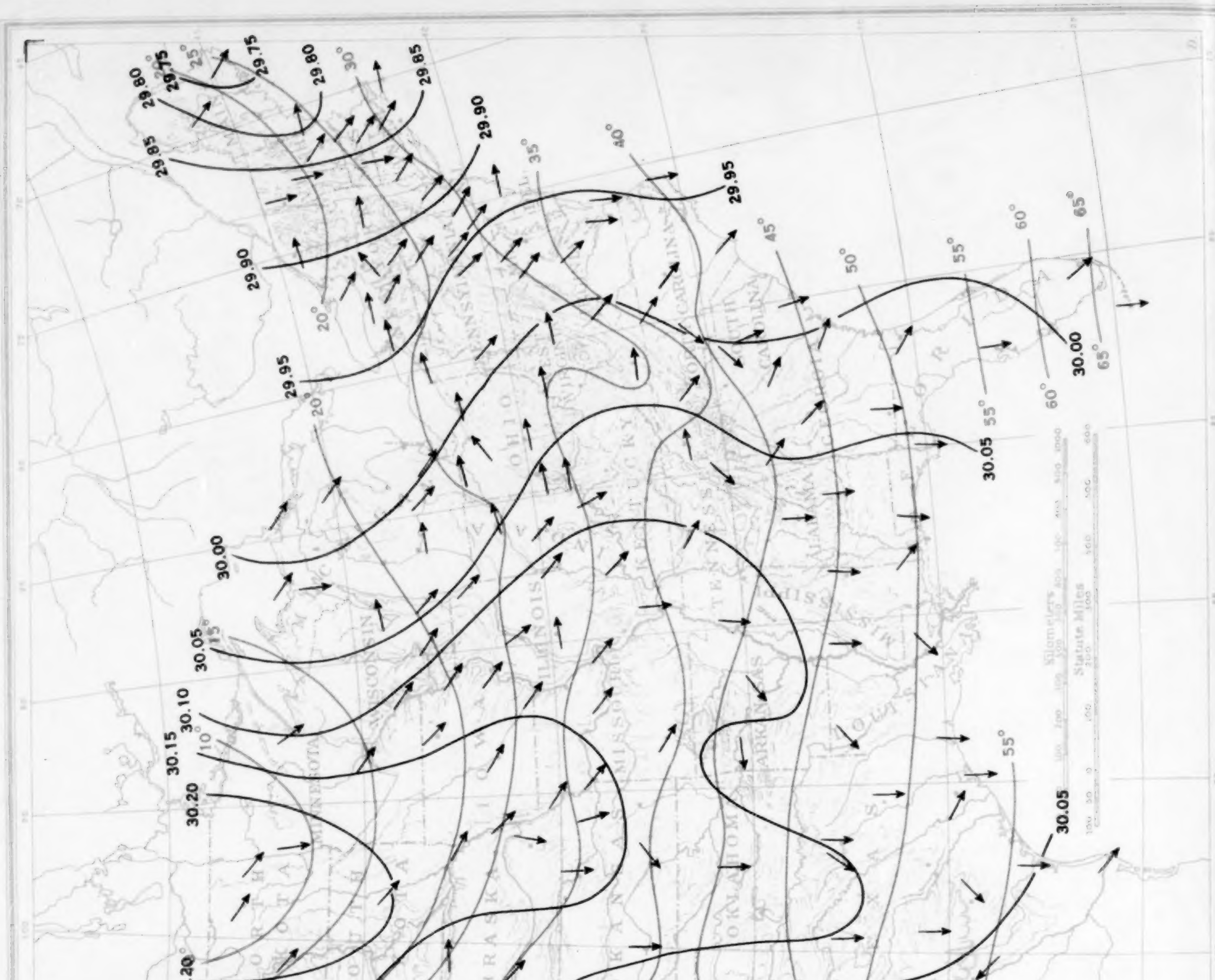


Chart VII. Total Snowfall, Inches, February 1941. (Inset) Depth of Snow on the Ground at 7:30 p.m., Monday, February 24, 1941

Chart VIII. Isobars (mb) for 1,524 Meters (5,000 ft.) and Isotherms (°C.) and Resultant Winds for 1,500 Meters (m. s. l.) February 1941

Isobars and isotherms based on radiosonde observations at 12:30 a. m. (E. S. T.) and winds based on pilot-balloon observations at 5:00 a. m. (E. S. T.).

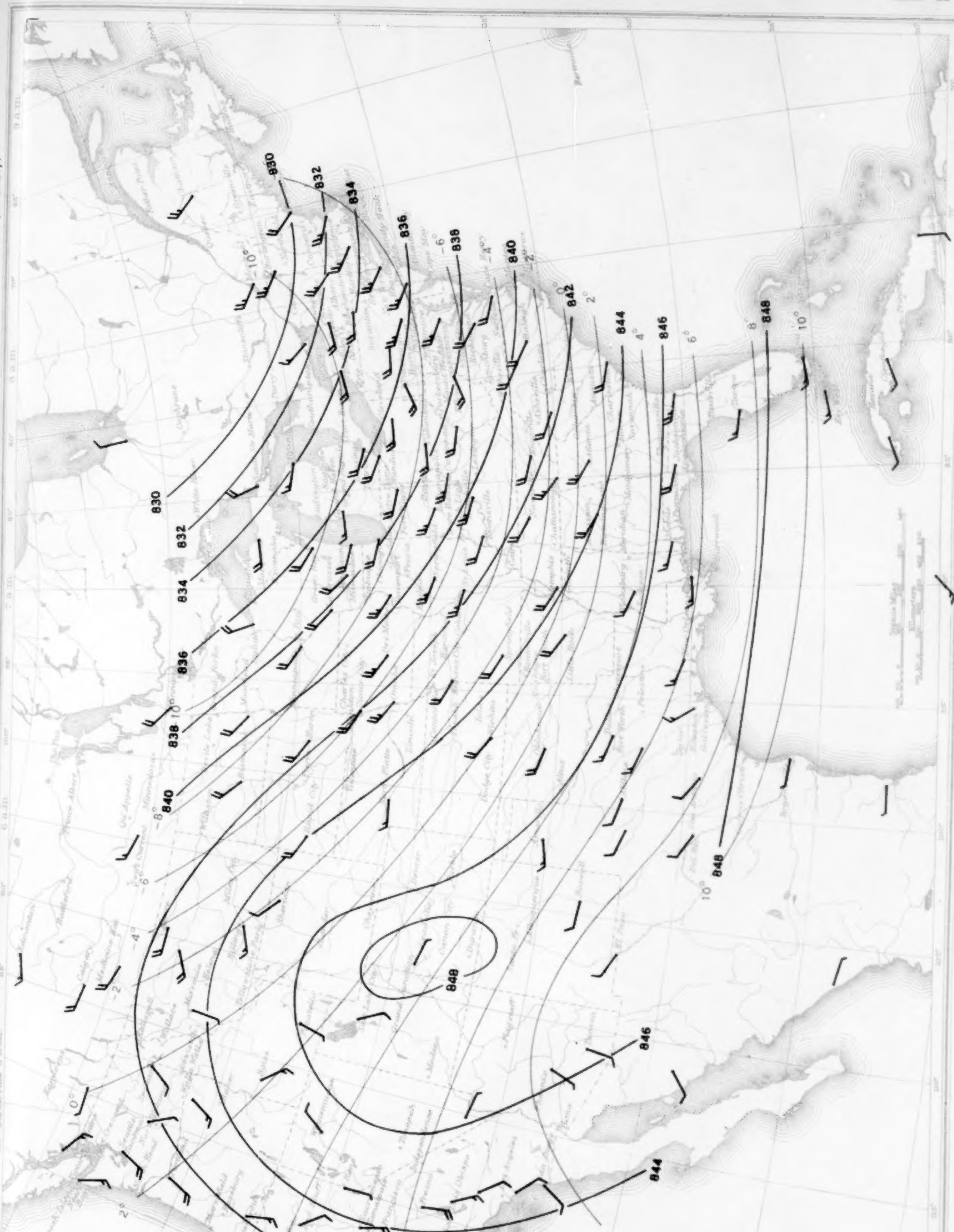


Chart VIII. Isobars (mb) for 1,524 Meters (5,000 ft.) and Isotherms (°C.) and Resultant Winds for 1,500 Meters (m. s. l.) February 1941

Isobars and isotherms based on radiosonde observations at 12:30 a. m. (E. S. T.) and winds based on pilot-balloon observations at 5:00 a. m. (E. S. T.).

Chart IX. Isobars (mb) Isotherms (°C.) 1:00 a. m. (E. S. T) and Resultant Winds 5:00 a. m. (E S. T.) for 3,000 Meters (m. s. l.) February 1941

Chart X. Isobars (mb) Isotherms (°C.) 1:00 a.m. (E. S. T.) and Resultant Winds 5:00 p.m. (E. S. T.) for 5,000 Meters (m. s. l.) February 1941

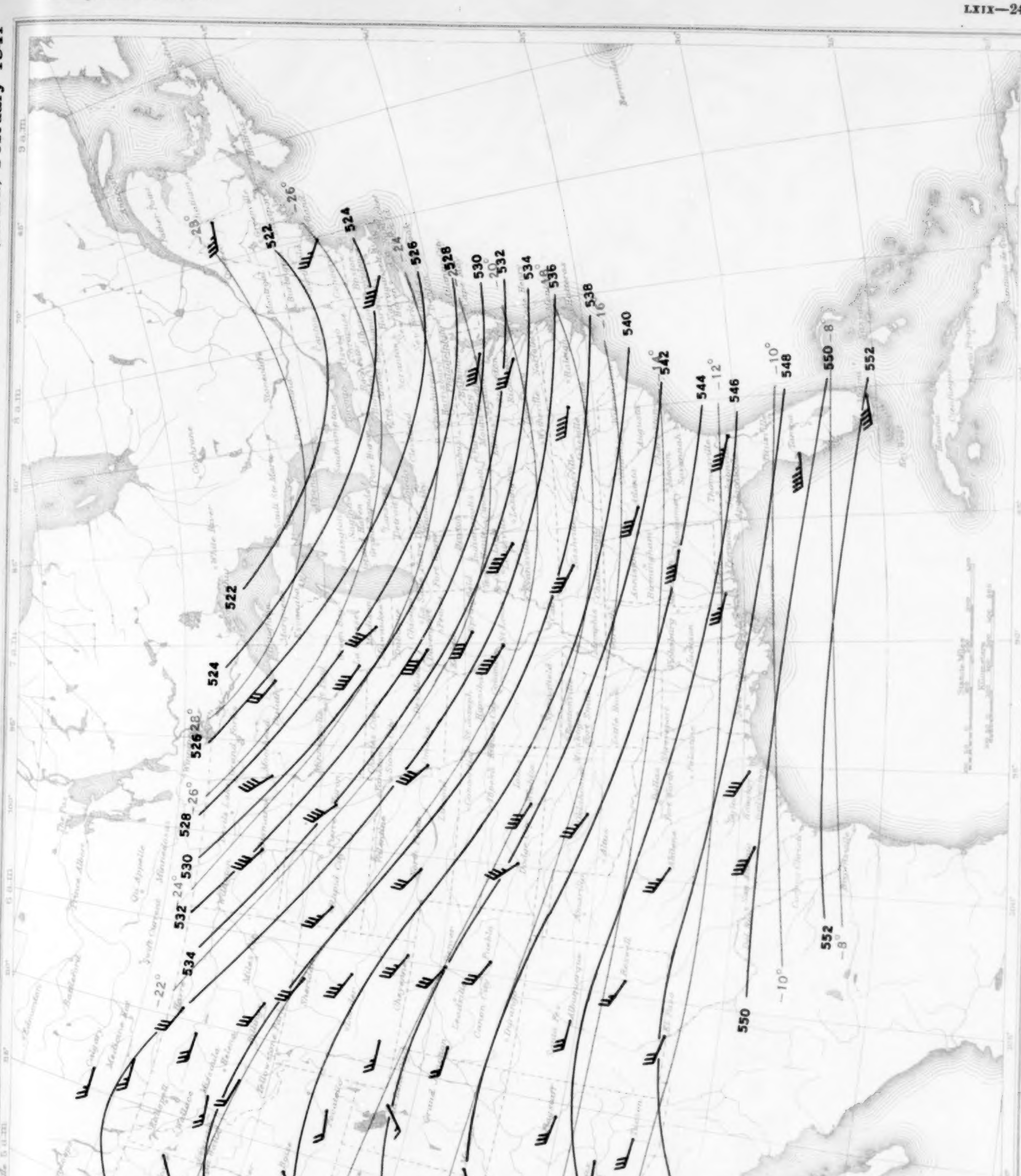


Chart XI. Isobars (mb) Isotherms (°C.) 1:00 a.m. (E.S.T.) and Resultant Winds 5:00 p.m. (E.S.T.) for 10,000 Meters (m.s.l.) February 1941